University of Southern Queensland

Met Office

# Adapting the CoMorph convection scheme for high resolution modelling

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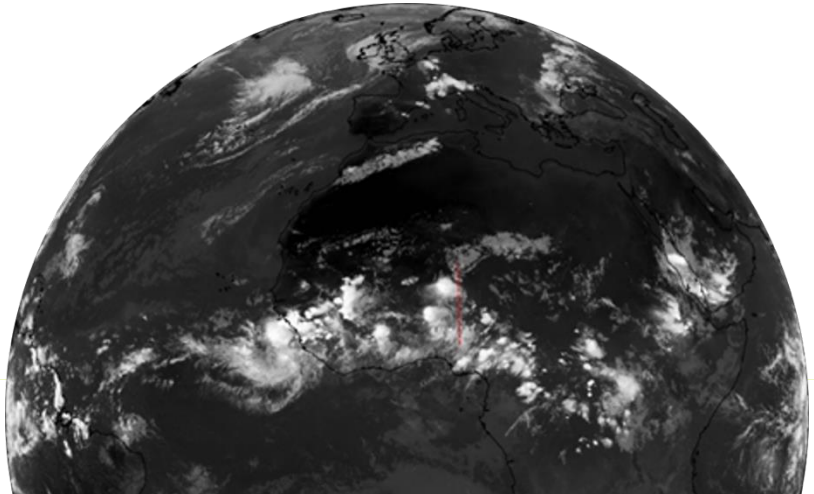
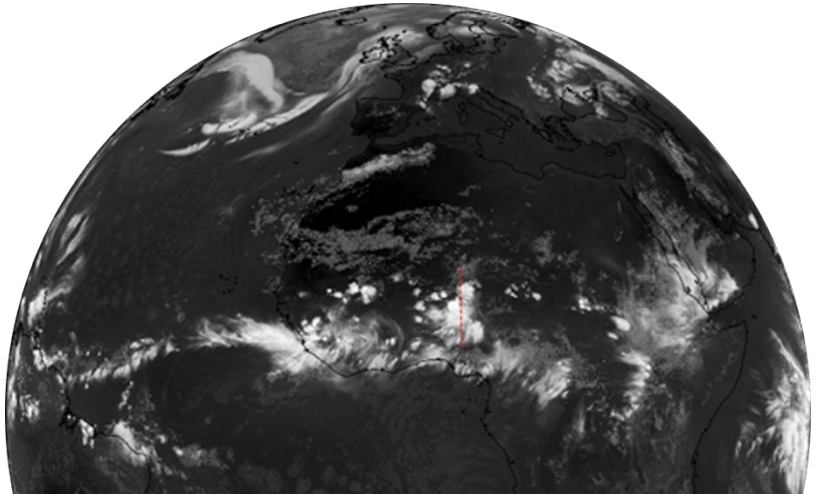
# Global NWP Trailblazer

- 5 km atmosphere/10 km ocean
- Exploring convective greyzone
- Opportunity for early adoption of new physics
- Preparing for future km-scale global ensemble
- Developments beneficial for all resolutions and time-scales

MSG satellite



5km UM simulation



Lorenzo Tomassini

# CoMorph-A Trailblazer testing (~5km)

Ticket: https://code.metoffice.gov.uk/trac/gmed/ticket/680

- Darwin nested suite
- Idealised experiments
- UKV (Adrian Lock)
- TC cases

**To what extent is CoMorph-A already scale-aware?**

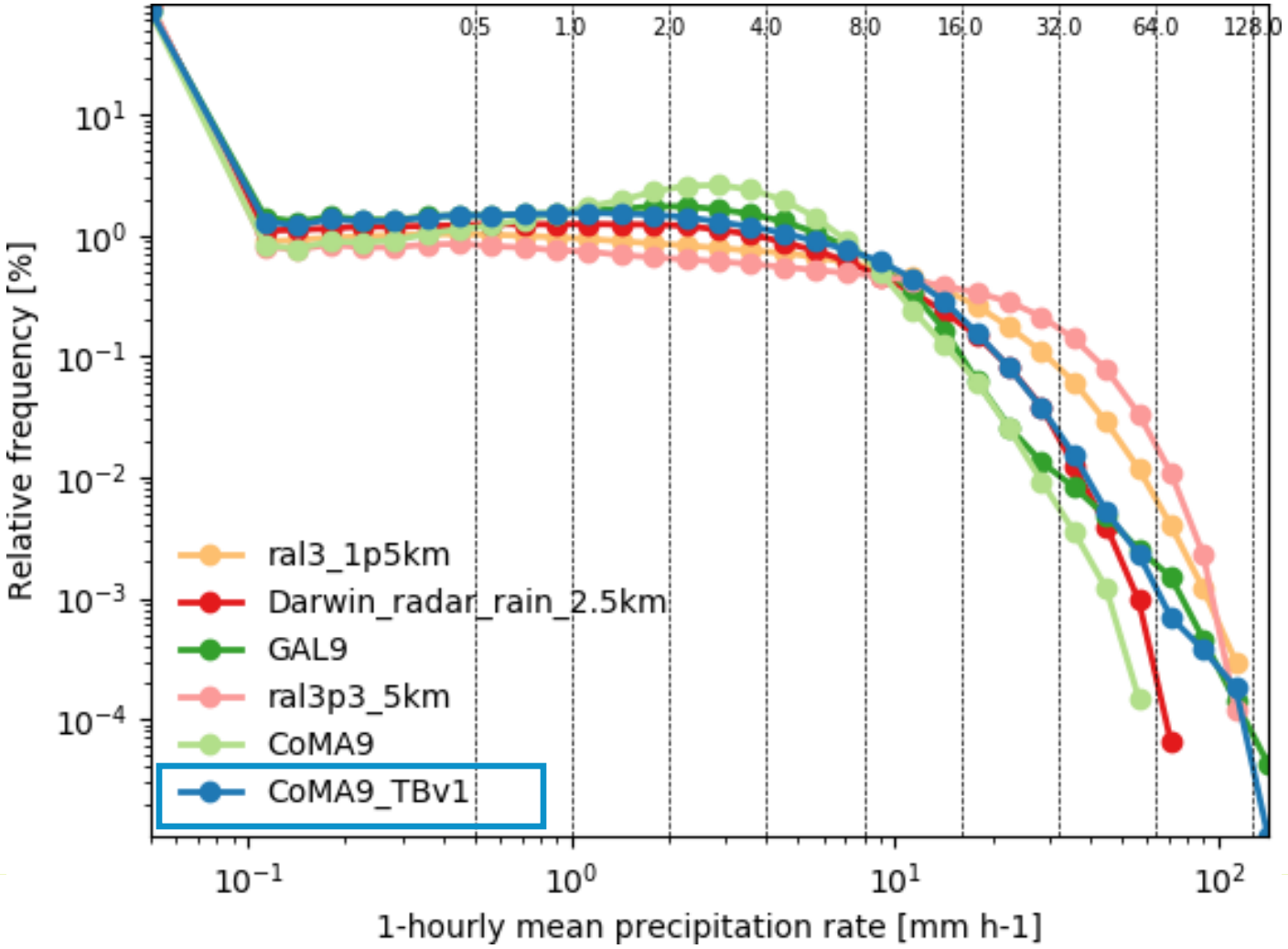
# CoMA9_TBv1

CoMA9 +

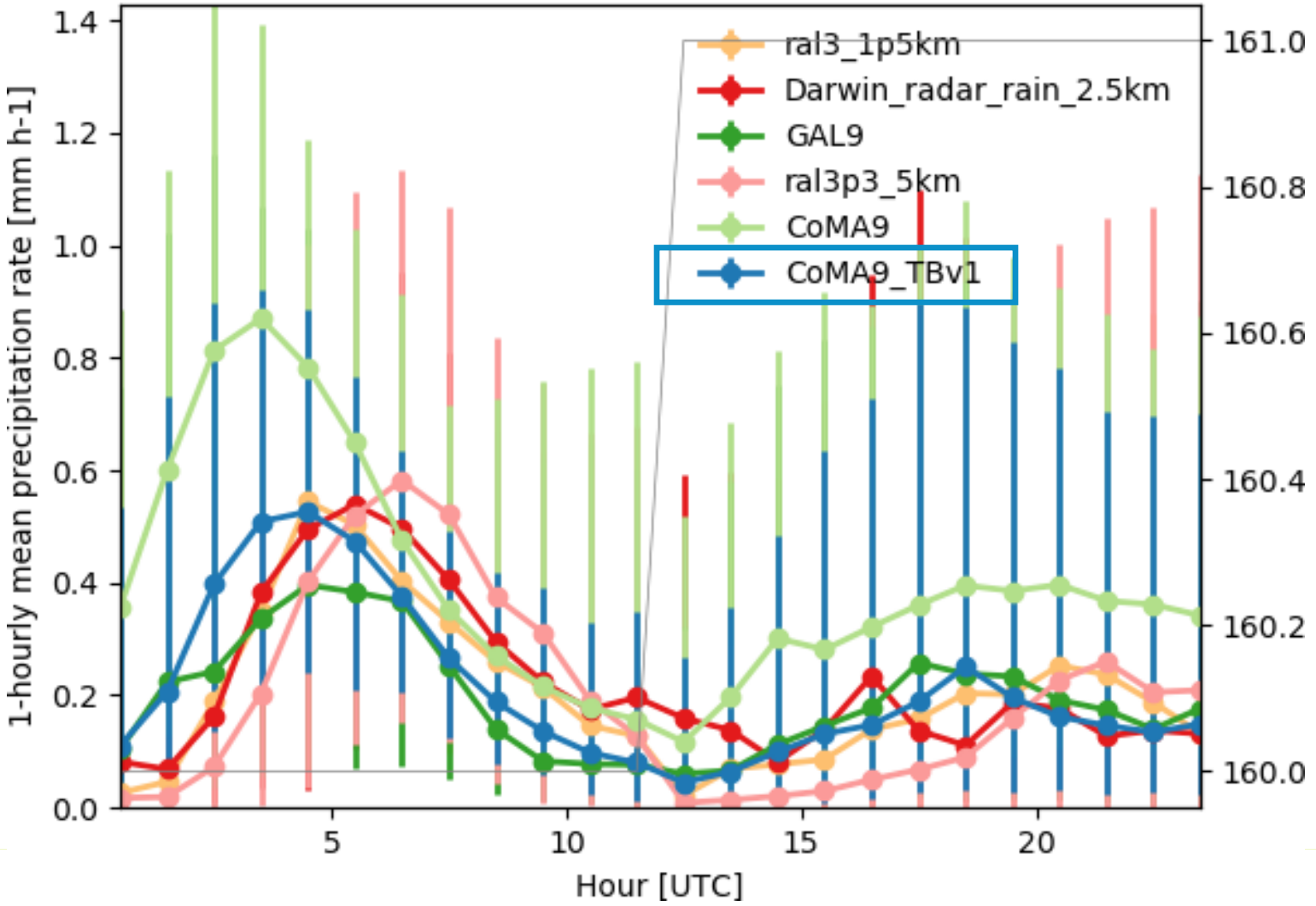
- Reduce initial moisture perturbations
- Reduce scaling of the initiating mass-flux at each height
- Increase of the precipitation rate leading to the maximum updraught size
- RAL3 moisture conservation settings
- Higher rain evaporation at high rain rates

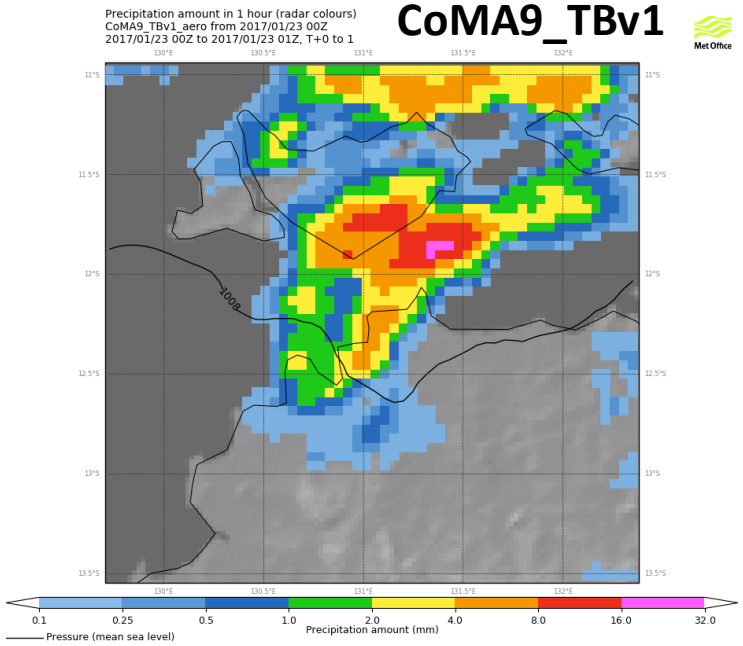
# Darwin nested suite

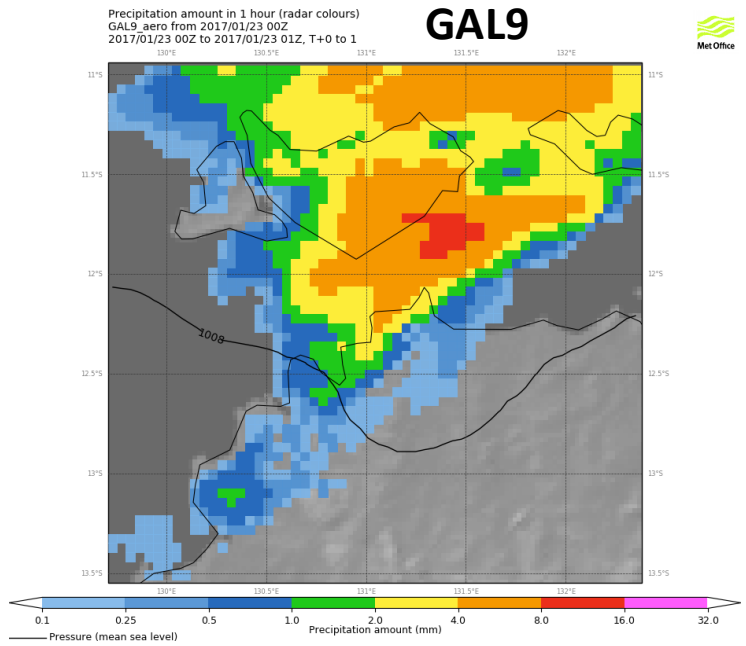
36 hours, every 12 hours,
21 Jan – 17 Mar 2017



# Diurnal cycle




Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 00Z to 2017/01/23 01Z, T+0 to 1
CoMA9_TBv1
Met Office
1008
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
Pressure (mean sea level)


Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 00Z to 2017/01/23 01Z, T+0 to 1
GAL9
Met Office
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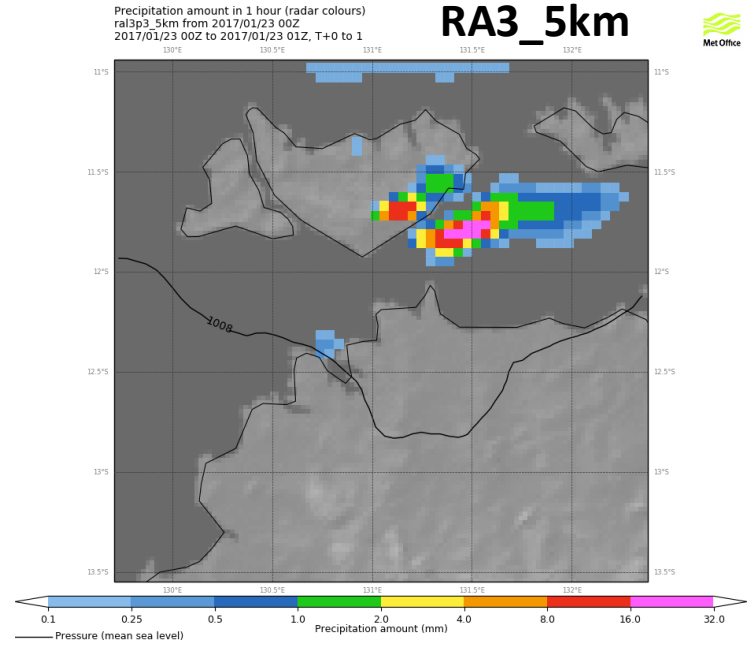
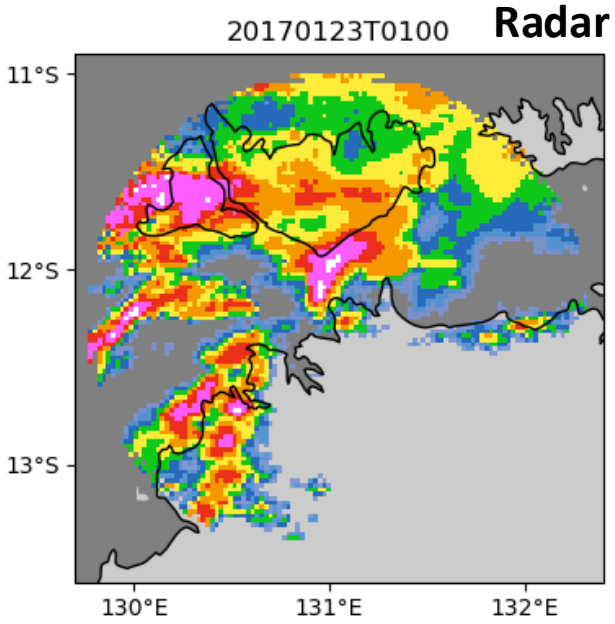
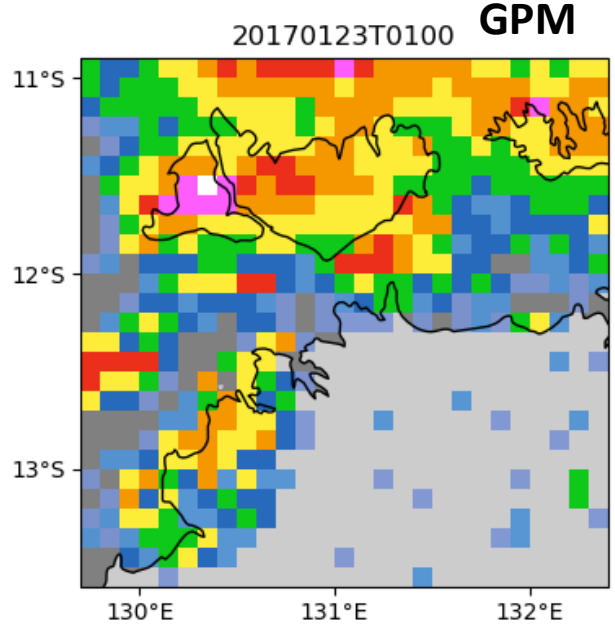
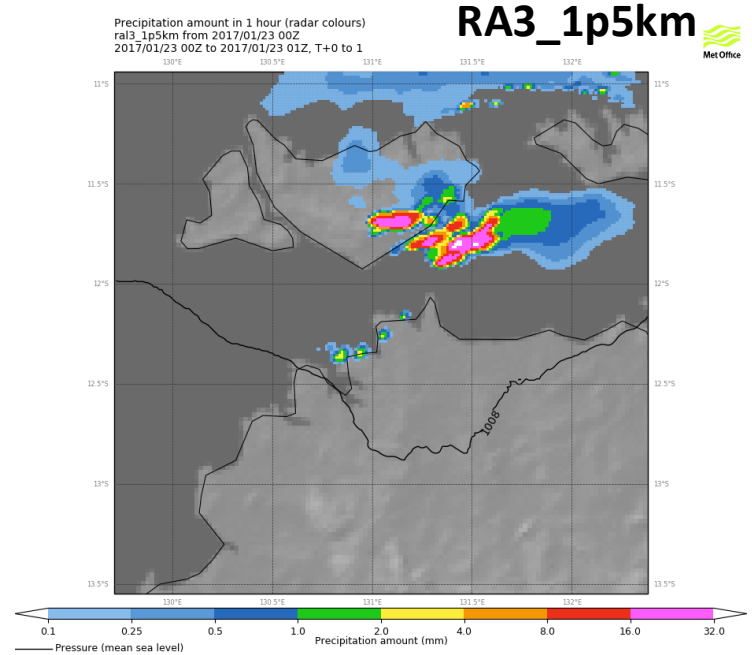
Precipitation amount (mm)
Pressure (mean sea level)


Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 00Z to 2017/01/23 01Z, T+0 to 1
RA3_5km
Met Office
1008
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
Pressure (mean sea level)

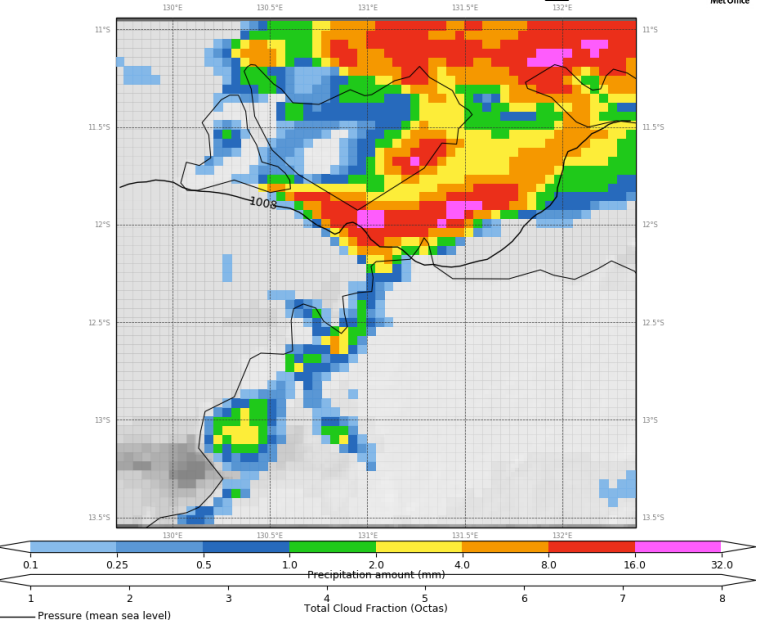

20170123T0100
Radar
11°S
12°S
13°S
130°E
131°E
132°E


20170123T0100
GPM
11°S
12°S
13°S
130°E
131°E
132°E


Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 00Z to 2017/01/23 01Z, T+0 to 1
RA3_1p5km
Met Office
1008
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
Pressure (mean sea level)

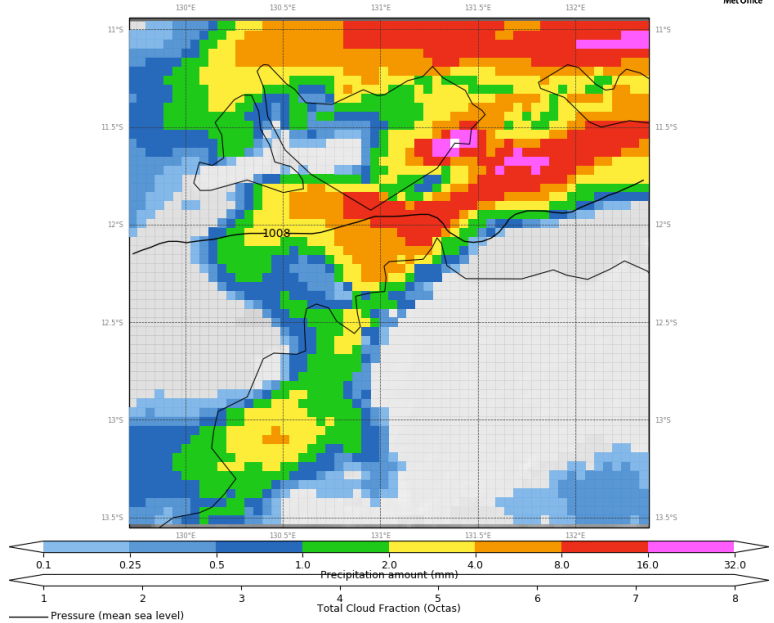
Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 01Z to 2017/01/23 02Z, T+1 to 2

# CoMA9_TBv1



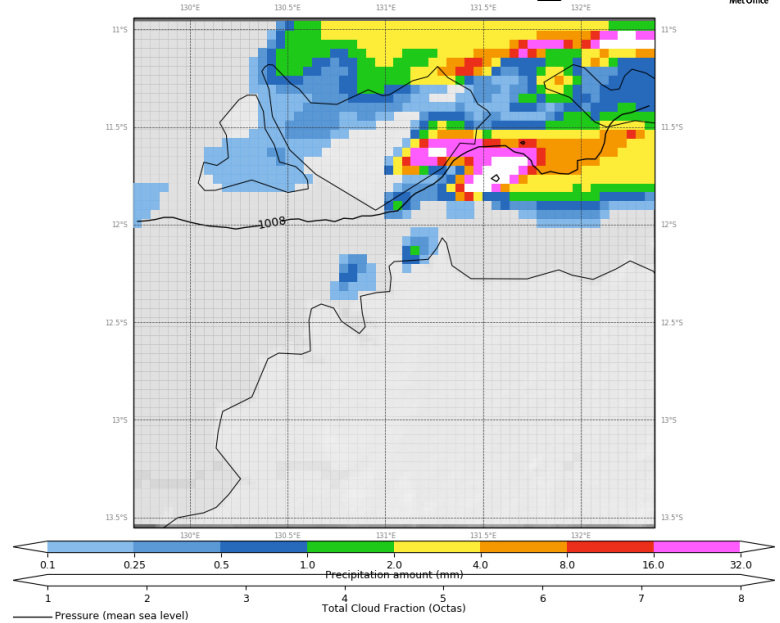

Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 01Z to 2017/01/23 02Z, T+1 to 2

# GAL9




Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 01Z to 2017/01/23 02Z, T+1 to 2

# RA3_5km




20170123T0200

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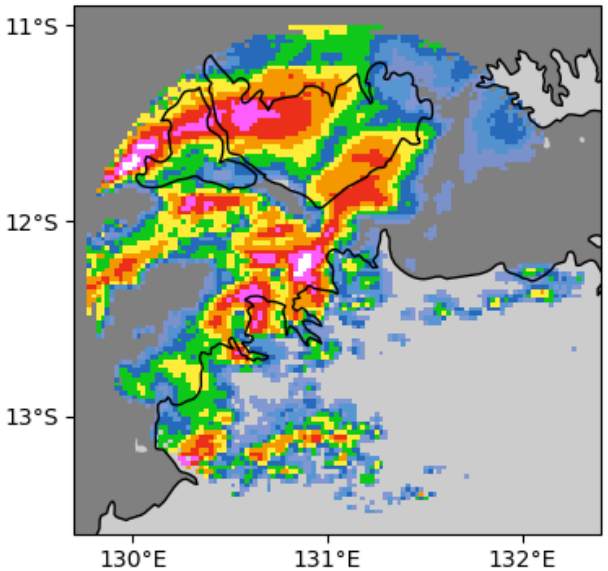


20170123T0200

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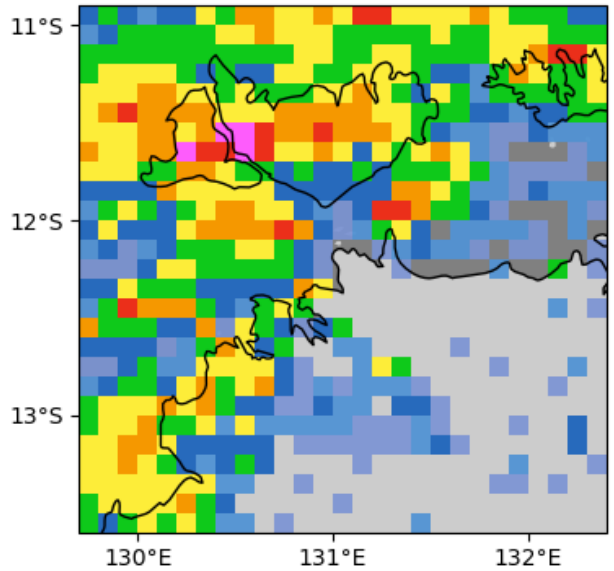
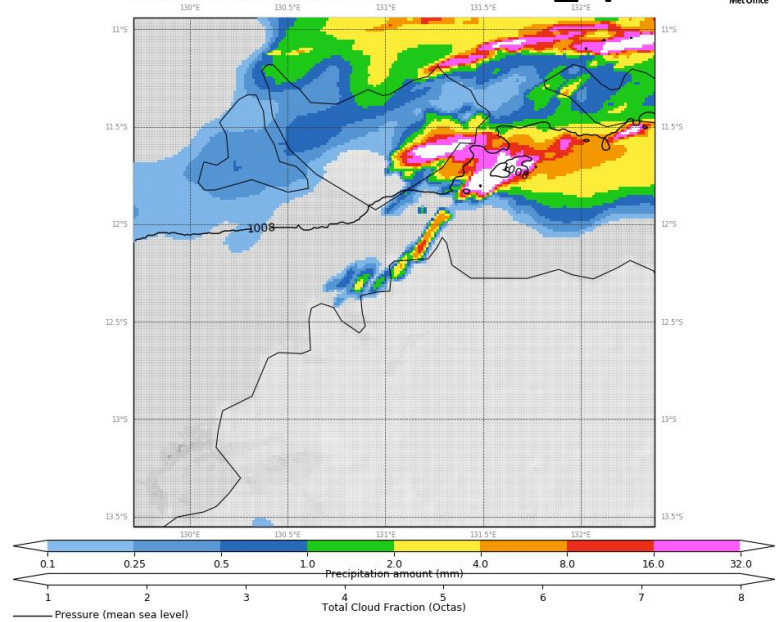


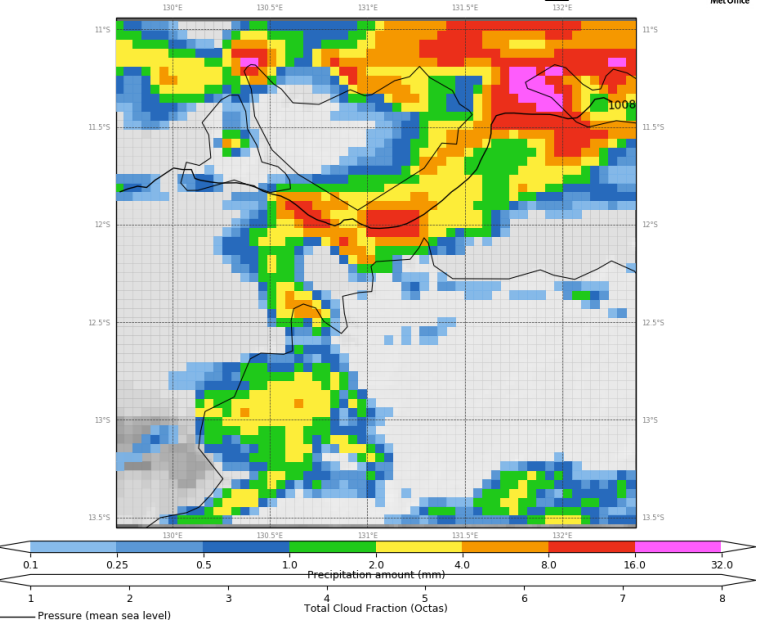

Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 01Z to 2017/01/23 02Z, T+1 to 2

# RA3_1p5km



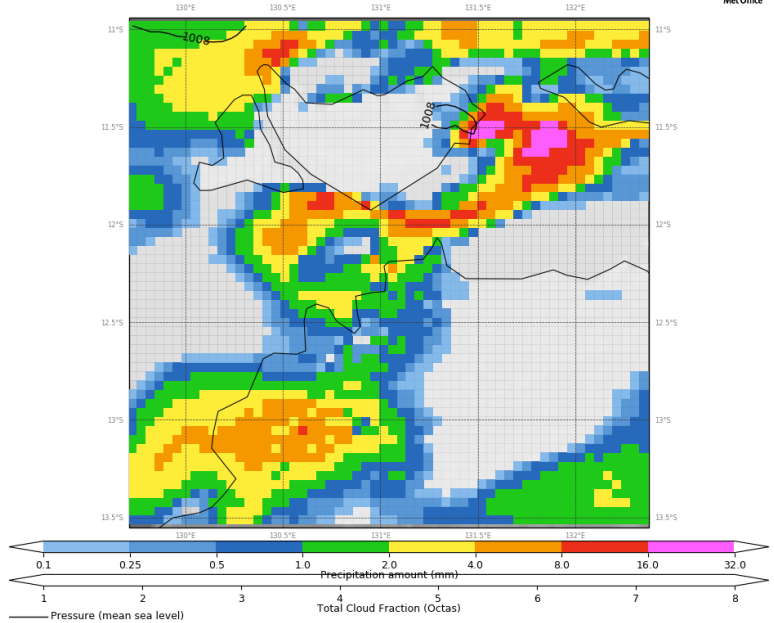
Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 02Z to 2017/01/23 03Z, T+2 to 3

# CoMA9_TBv1



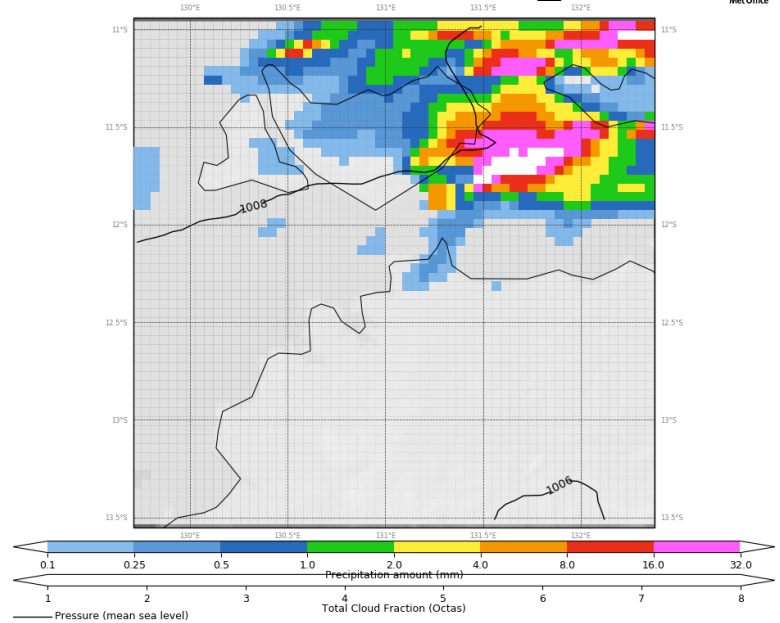

Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 02Z to 2017/01/23 03Z, T+2 to 3

# GAL9



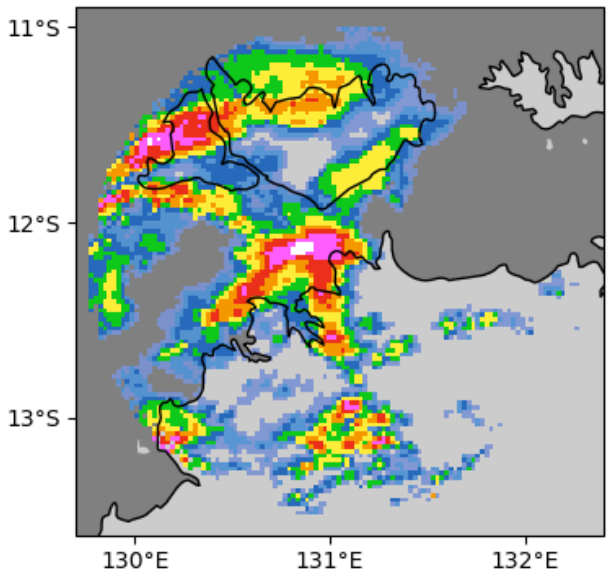

Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 02Z to 2017/01/23 03Z, T+2 to 3

# RA3_5km




20170123T0300

# Radar




20170123T0300

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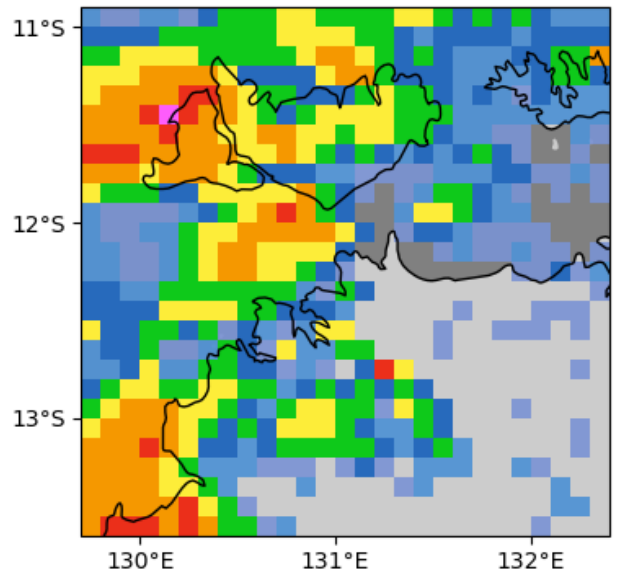
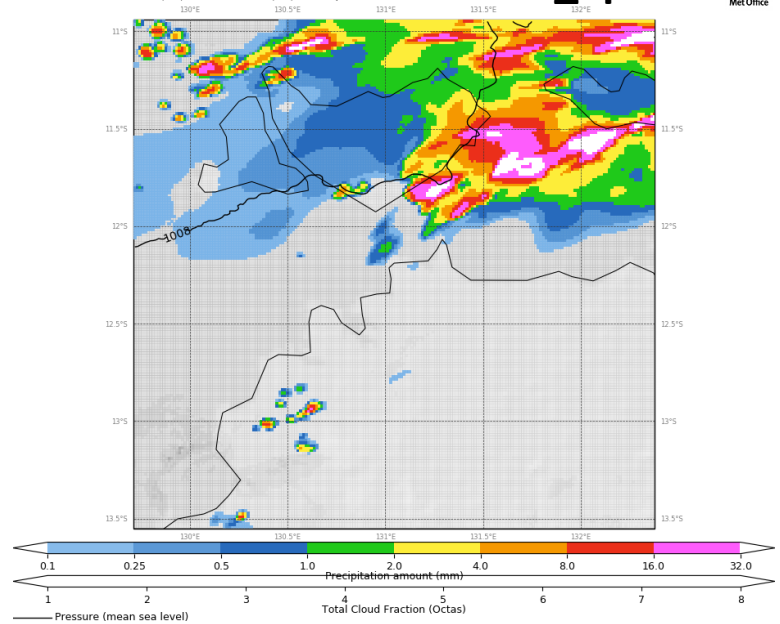
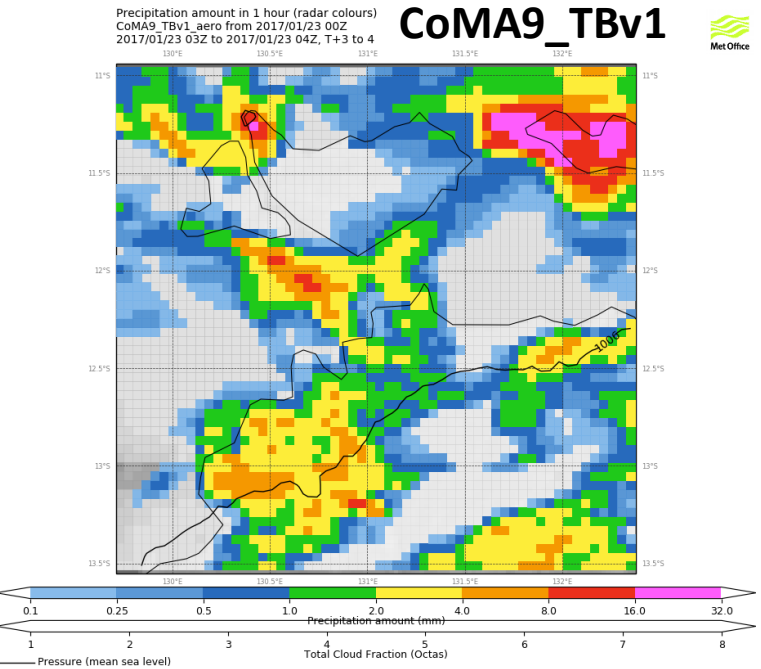



Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 02Z to 2017/01/23 03Z, T+2 to 3

# RA3_1p5km

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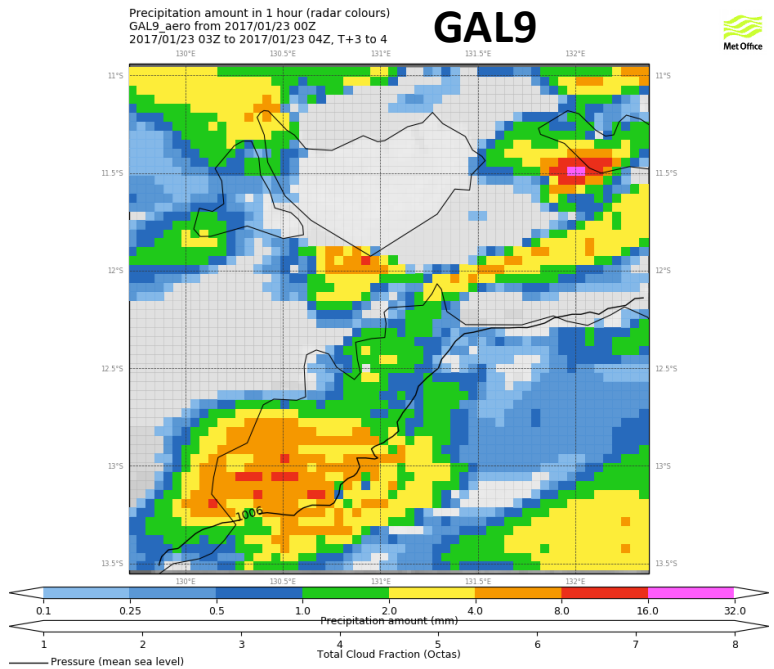
2017/01/23 03Z to 2017/01/23 04Z, T+3 to 4
CoMA9_TBv1
Met Office
1008
1006
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)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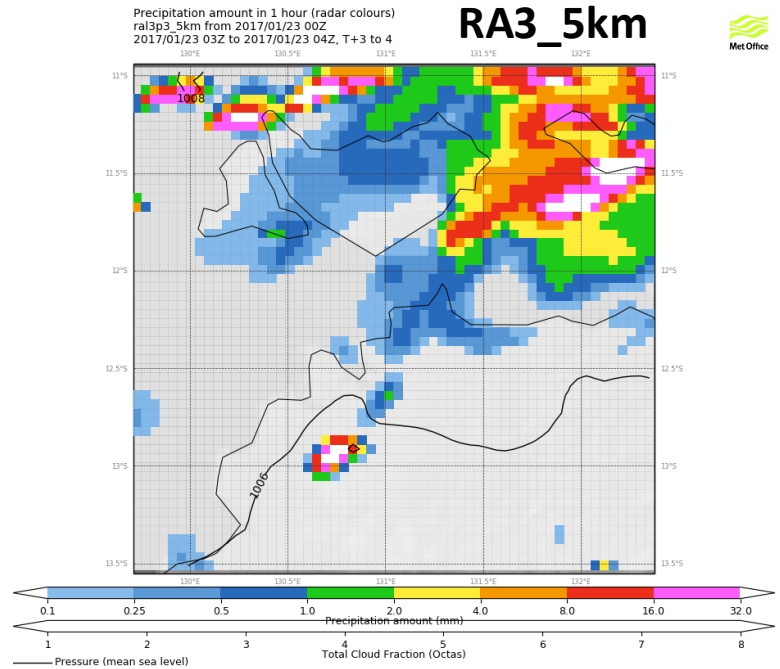
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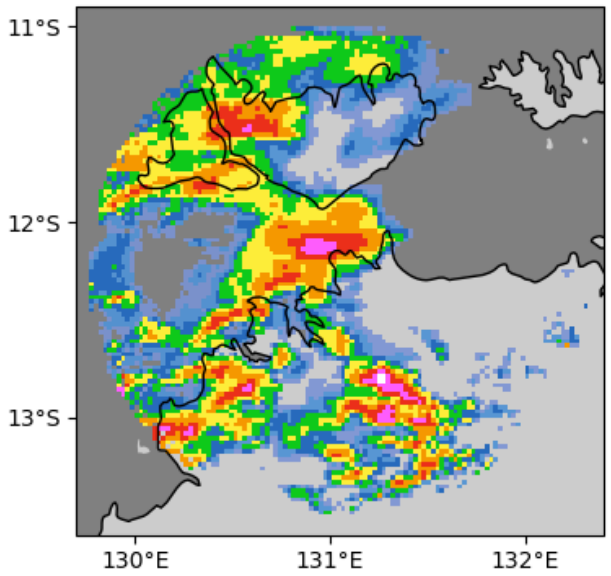
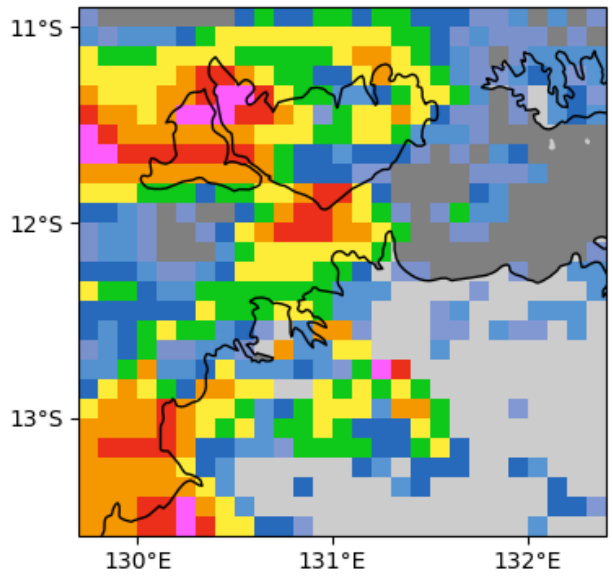

20170123T0400
Radar
11°S
12°S
13°S
130°E
131°E
132°E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GPM
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12°S
13°S
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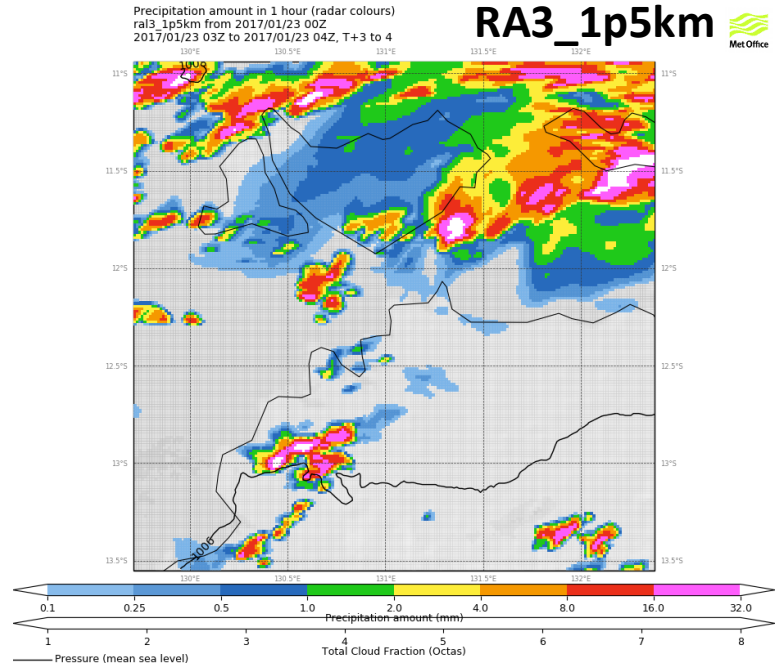
Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 03Z to 2017/01/23 04Z, T+3 to 4
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Precipitation amount (mm)
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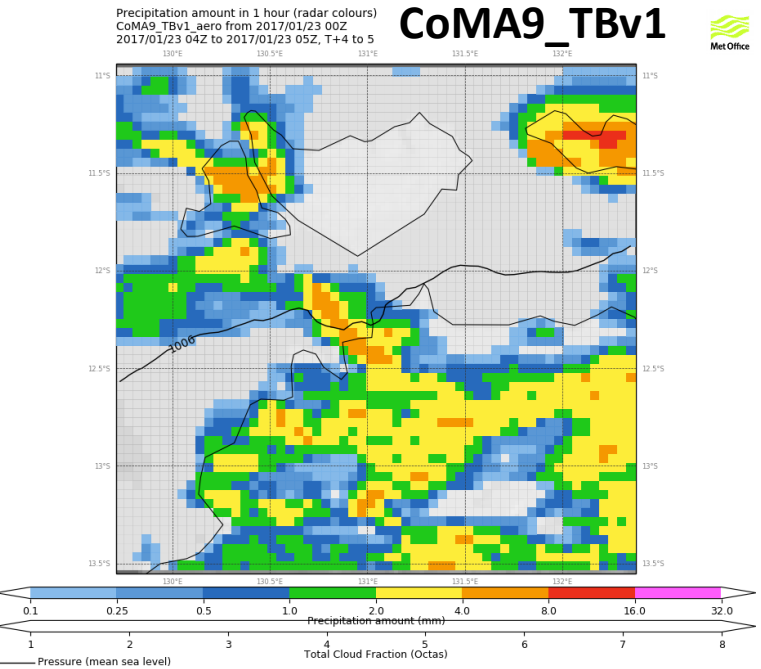
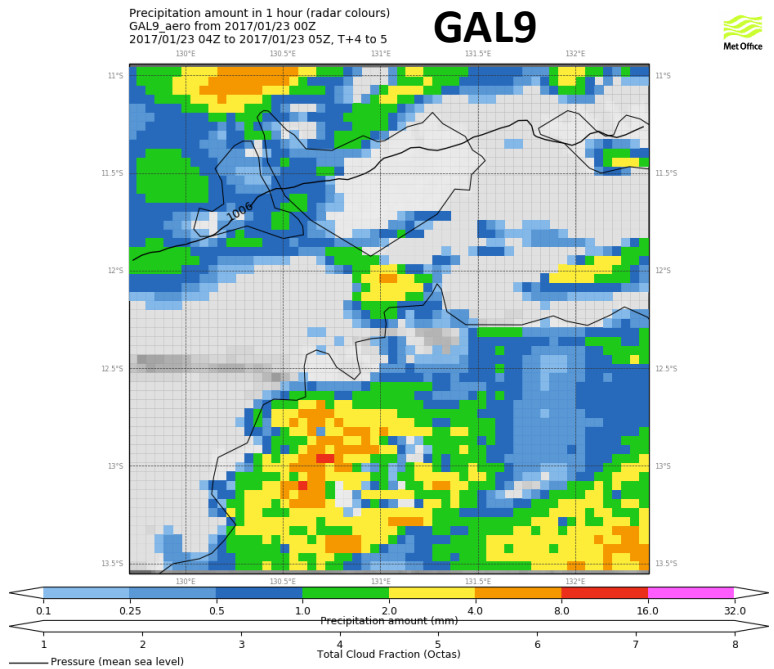
Total Cloud Fraction (Octas)
Pressure (mean sea level)


Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 04Z to 2017/01/23 05Z, T+4 to 5
CoMA9_TBv1
Met Office
1006
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)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GAL9_aero from 2017/01/23 00Z
2017/01/23 04Z to 2017/01/23 05Z, T+4 to 5
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Precipitation amount (mm)
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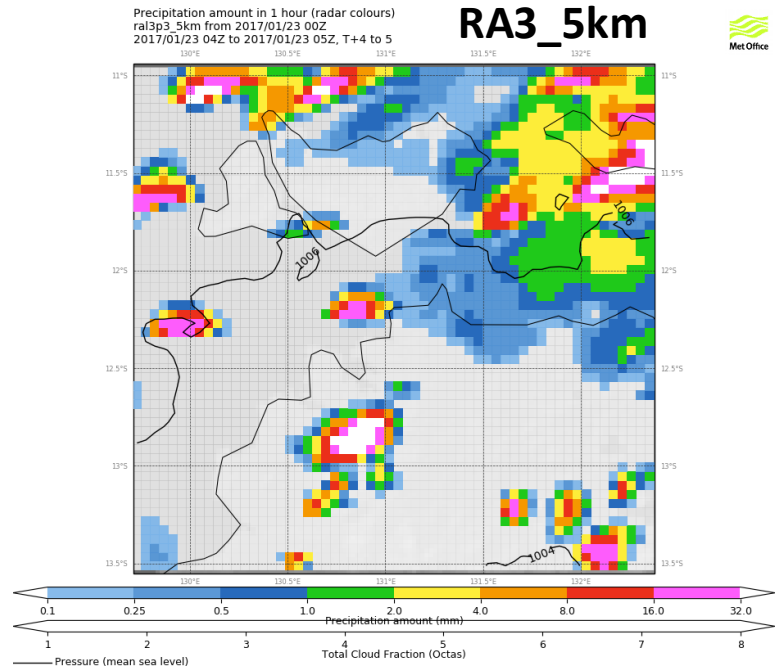
Total Cloud Fraction (Octas)
Pressure (mean sea level)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2017/01/23 04Z to 2017/01/23 05Z, T+4 to 5
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Precipitation amount (mm)
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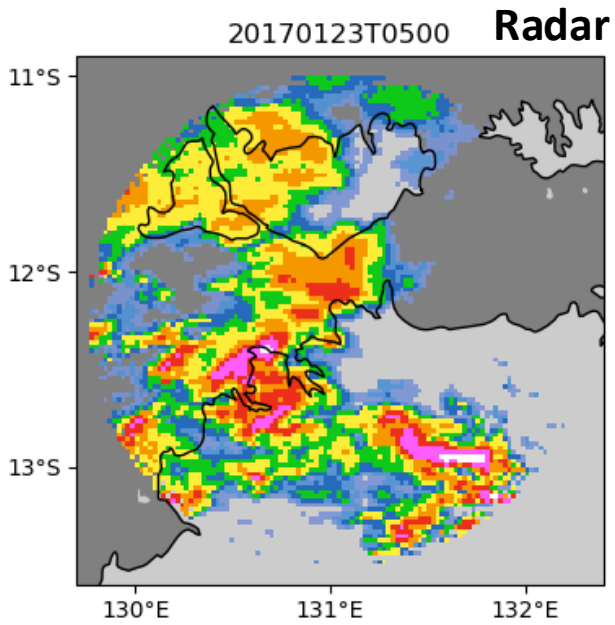
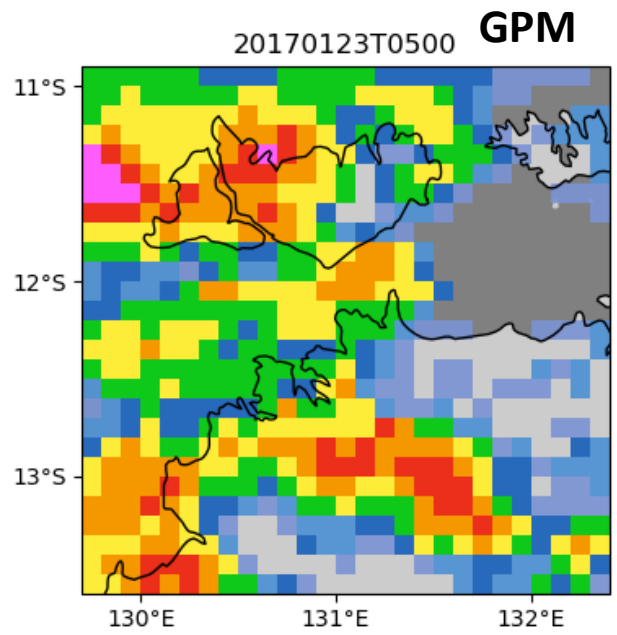
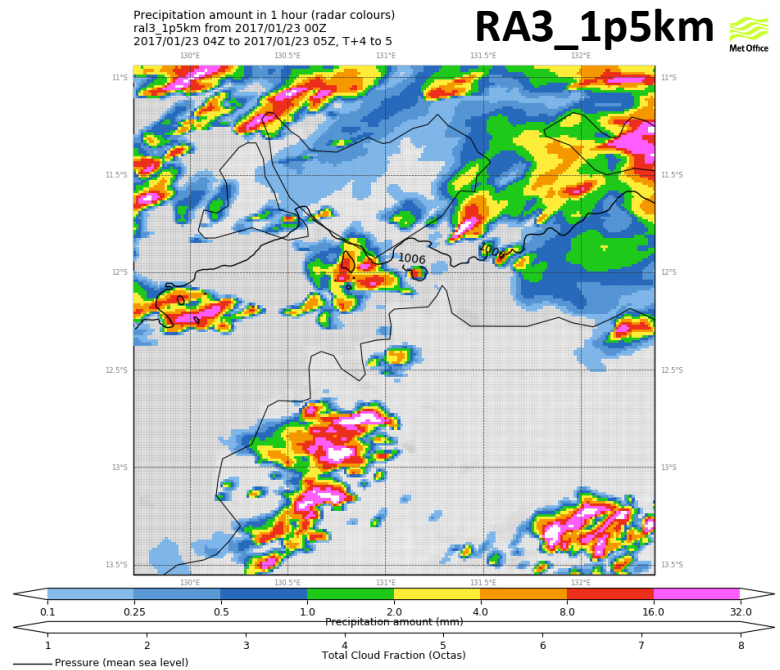
Total Cloud Fraction (Octas)
Pressure (mean sea level)

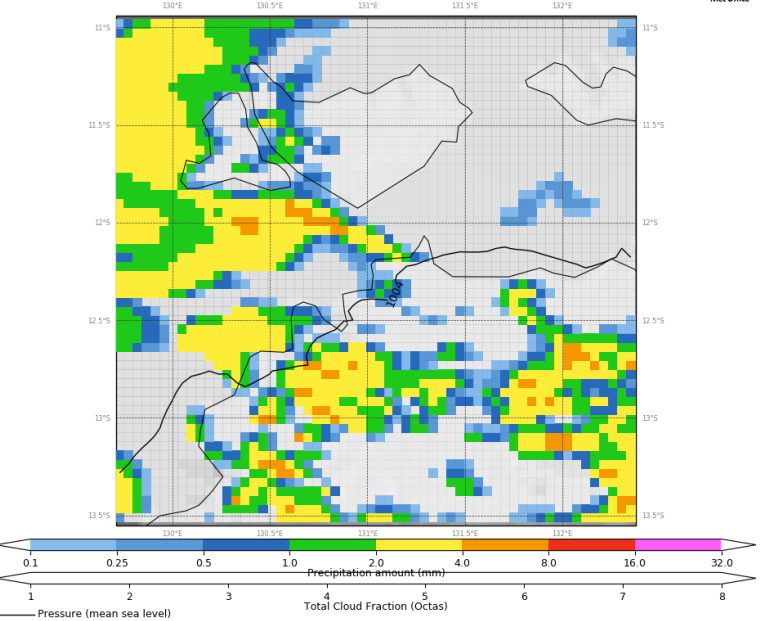

20170123T0500
Radar
11°S
12°S
13°S
130°E
131°E
132°E


20170123T0500
GPM
11°S
12°S
13°S
130°E
131°E
132°E


Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 04Z to 2017/01/23 05Z, T+4 to 5
RA3_1p5km
Met Office
1006
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)

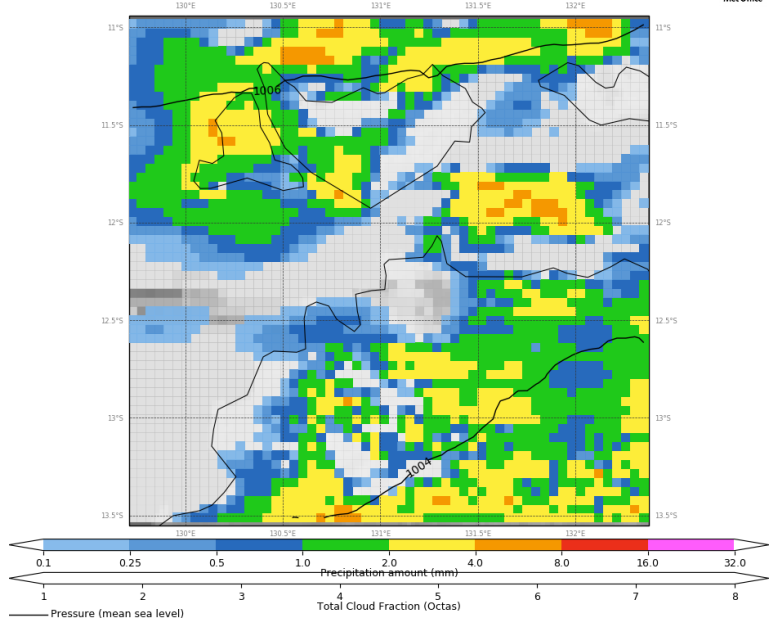
Precipitation amount in 1 hour (radar colours)
CoMA9_eta_aero from 2017/01/23 00Z
2017/01/23 05Z to 2017/01/23 06Z, T+5 to 6

# CoMA9_TBv1



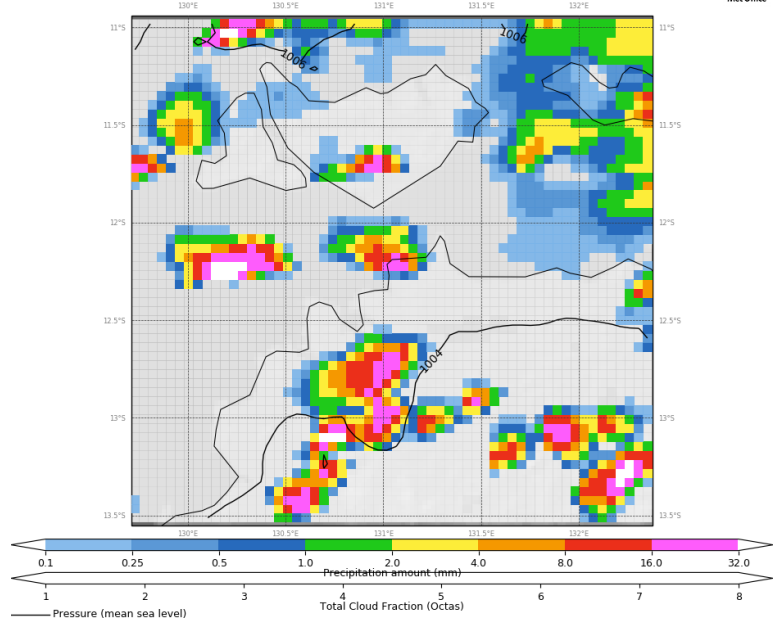

Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 05Z to 2017/01/23 06Z, T+5 to 6

# GAL9



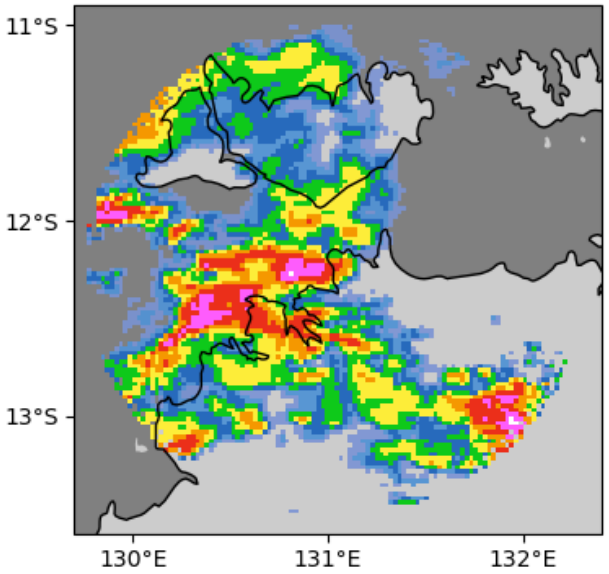

Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 05Z to 2017/01/23 06Z, T+5 to 6

# RA3_5km



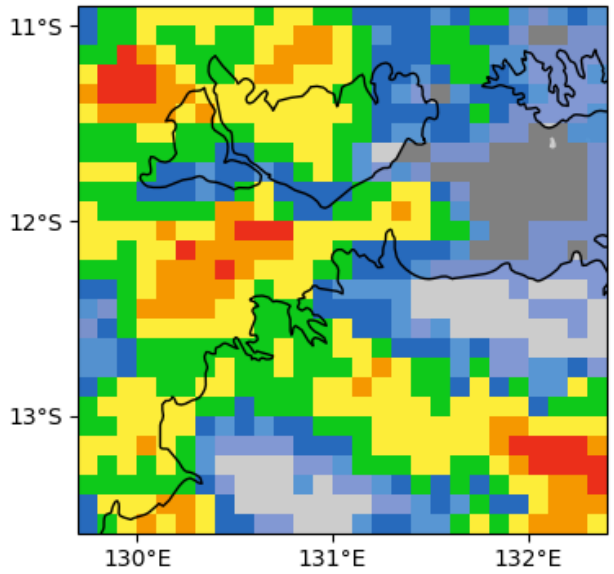

20170123T0600

# Radar



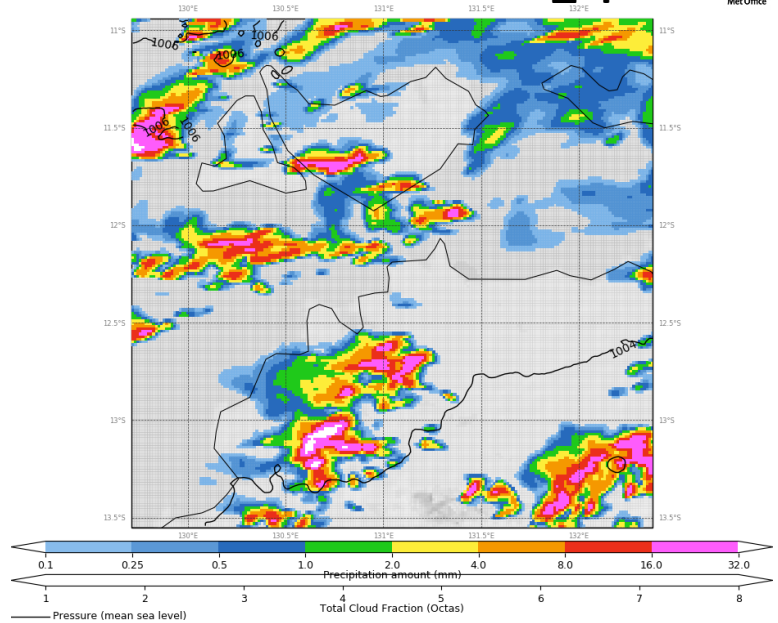

20170123T0600

# GPM



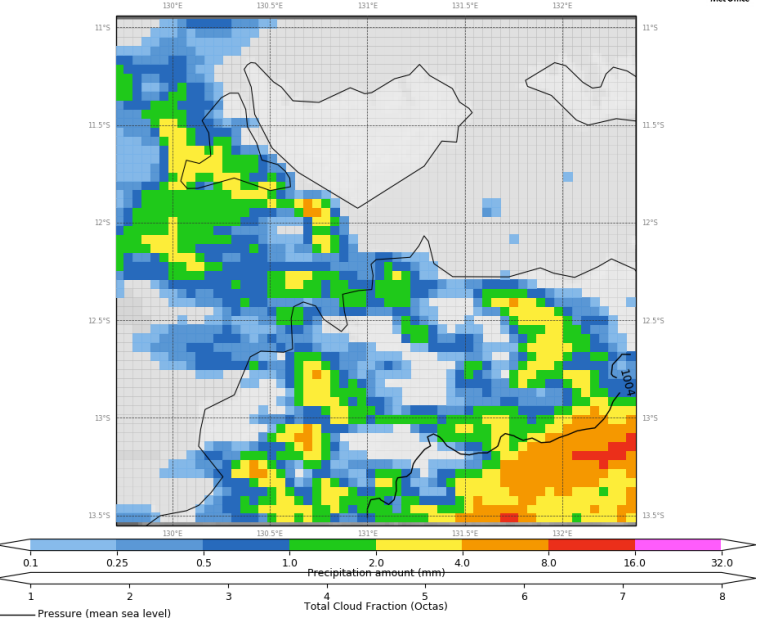

Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 05Z to 2017/01/23 06Z, T+5 to 6

# RA3_1p5km



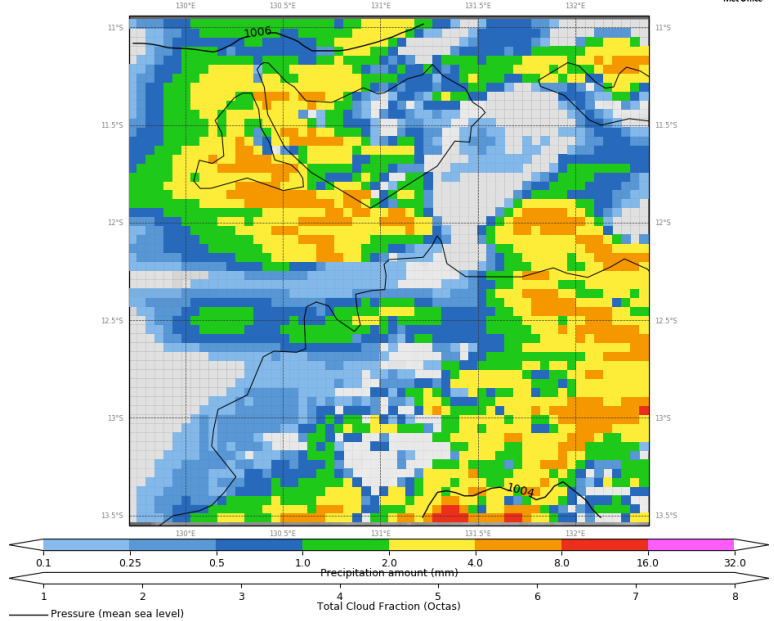
Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 06Z to 2017/01/23 07Z, T+6 to 7

# CoMA9_TBv1



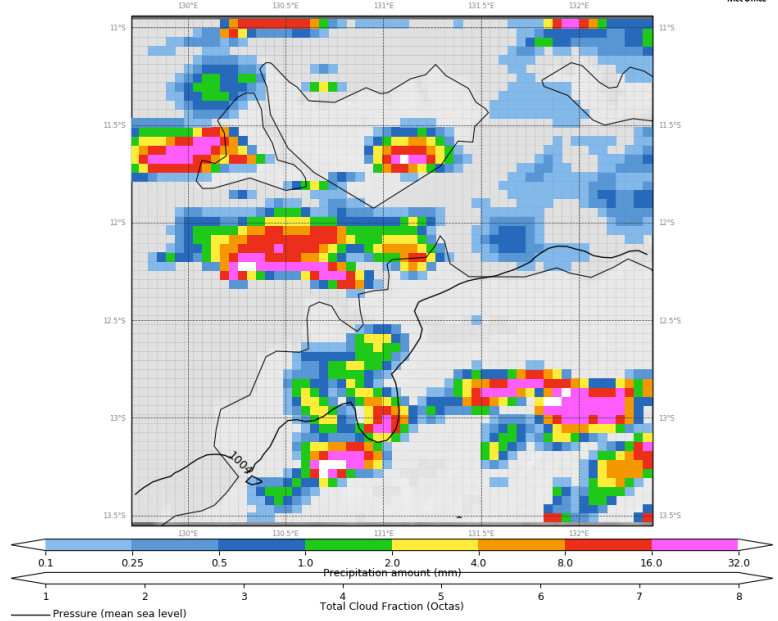

Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 06Z to 2017/01/23 07Z, T+6 to 7

# GAL9



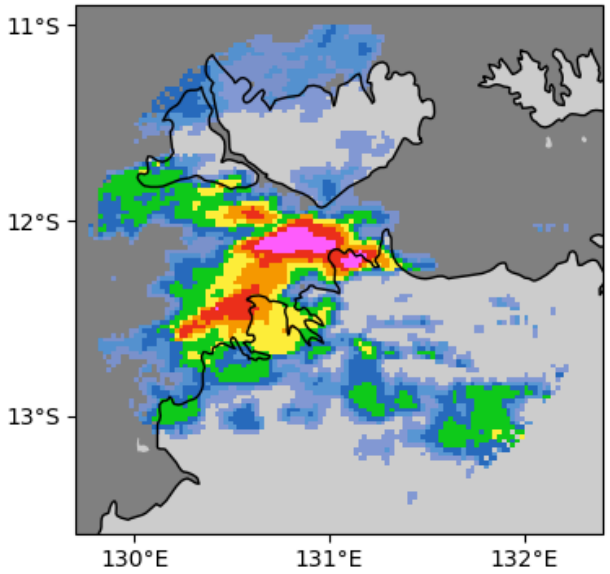

Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 06Z to 2017/01/23 07Z, T+6 to 7

# RA3_5km



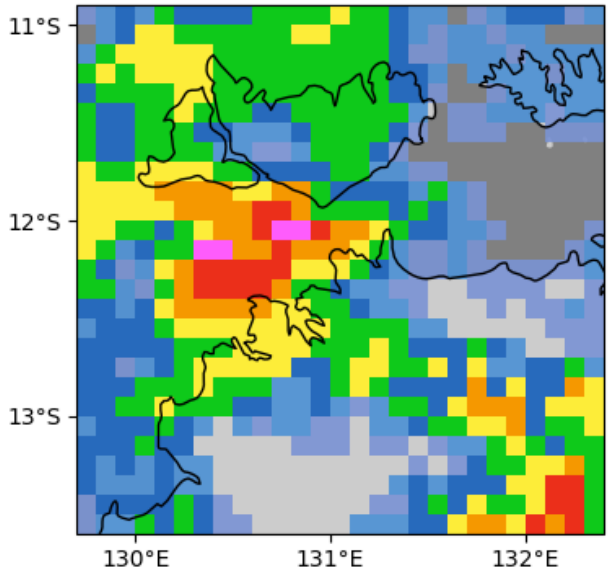

20170123T0700

# Radar



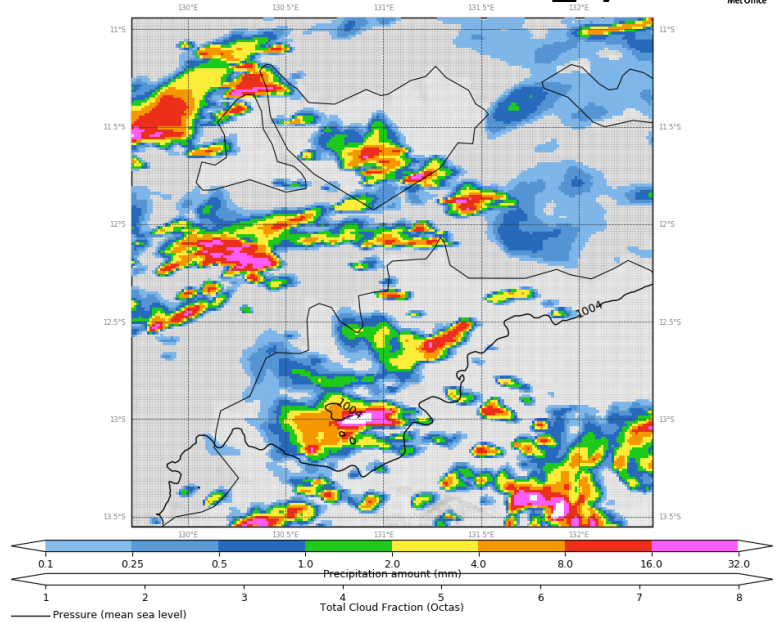

20170123T0700

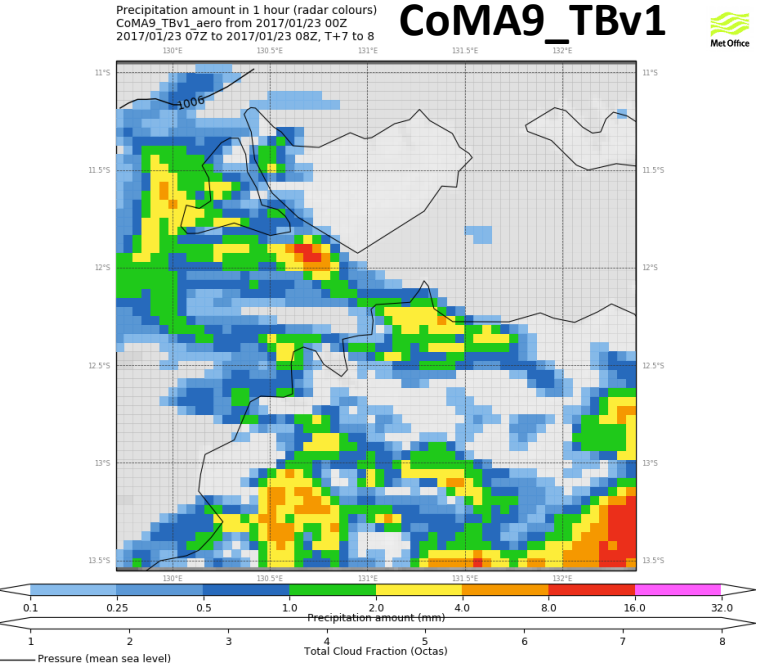
# GPM

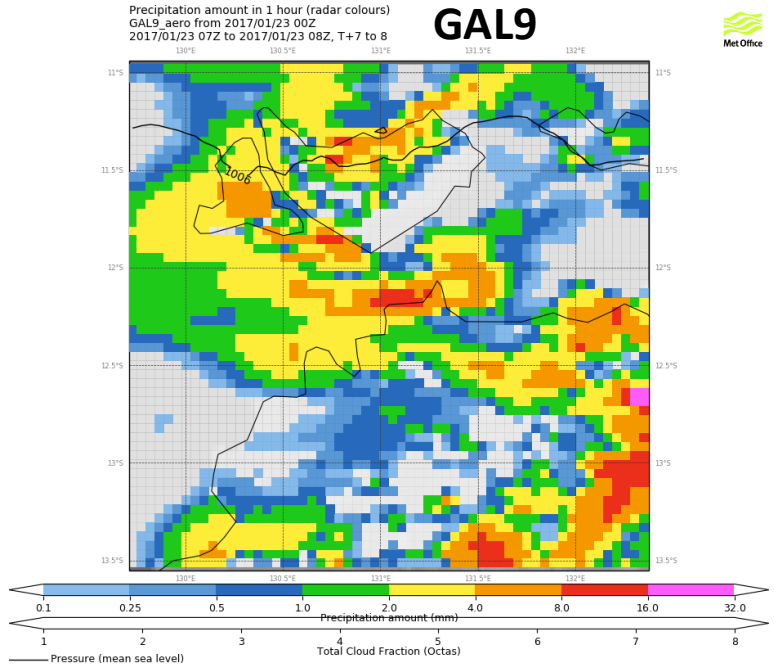


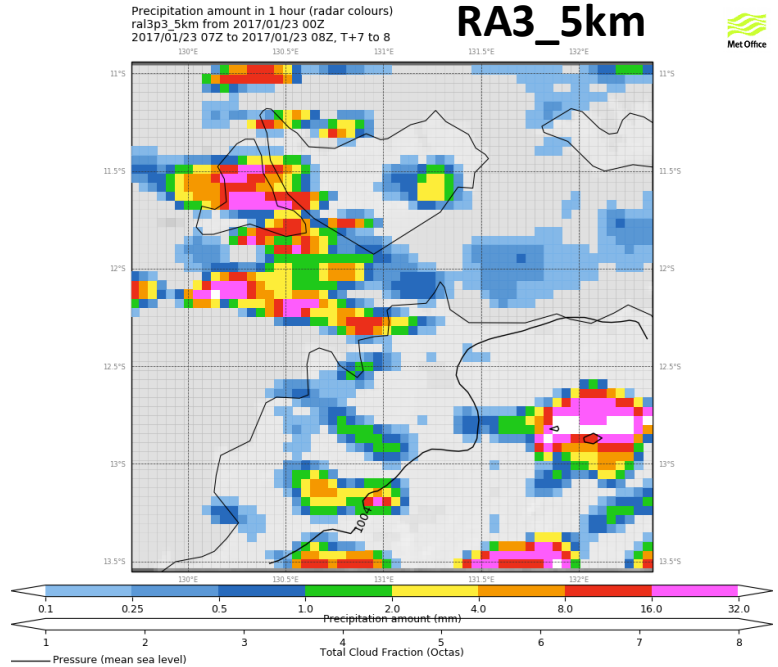

Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 06Z to 2017/01/23 07Z, T+6 to 7

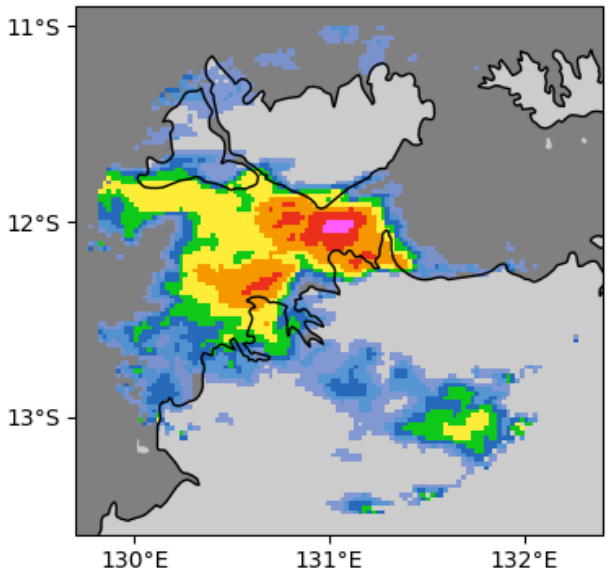
# RA3_1p5km

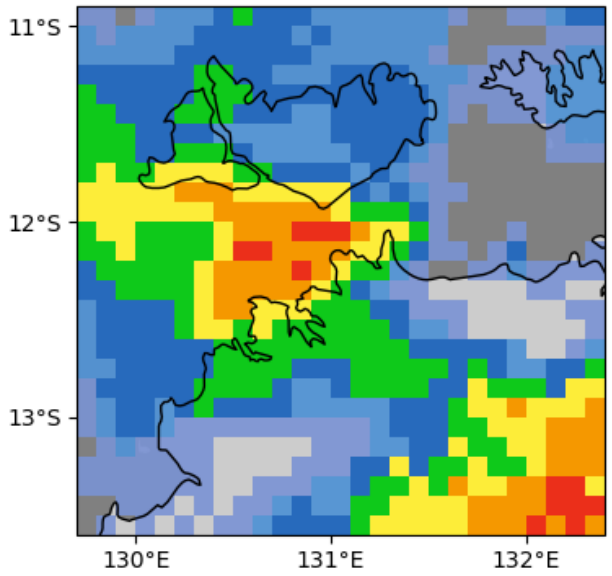


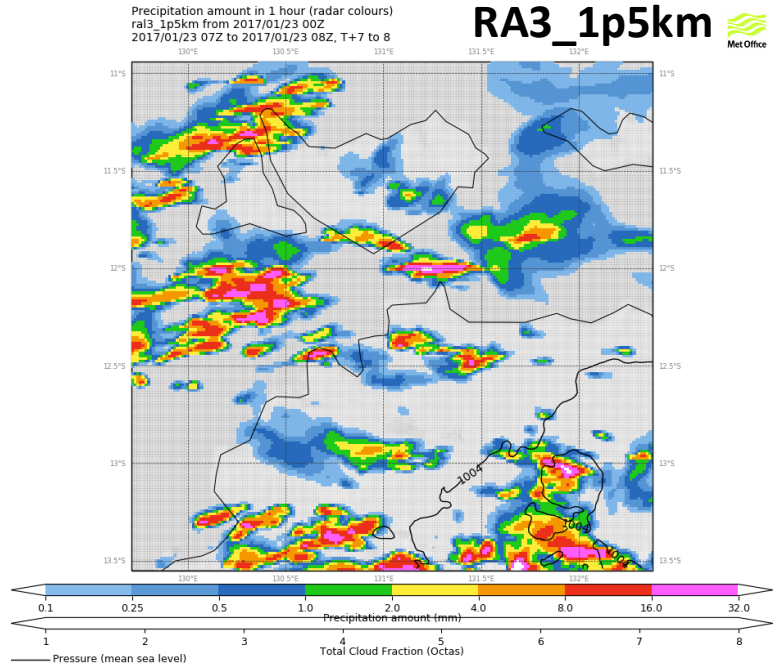

Precipitation amount in 1 hour (radar colours)
CoMA9_TBv1_aero from 2017/01/23 00Z
2017/01/23 07Z to 2017/01/23 08Z, T+7 to 8
CoMA9_TBv1
Met Office
1006
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)


Precipitation amount in 1 hour (radar colours)
GAL9_aero from 2017/01/23 00Z
2017/01/23 07Z to 2017/01/23 08Z, T+7 to 8
GAL9
Met Office
1006
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)


Precipitation amount in 1 hour (radar colours)
ral3p3_5km from 2017/01/23 00Z
2017/01/23 07Z to 2017/01/23 08Z, T+7 to 8
RA3_5km
Met Office
1004
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)

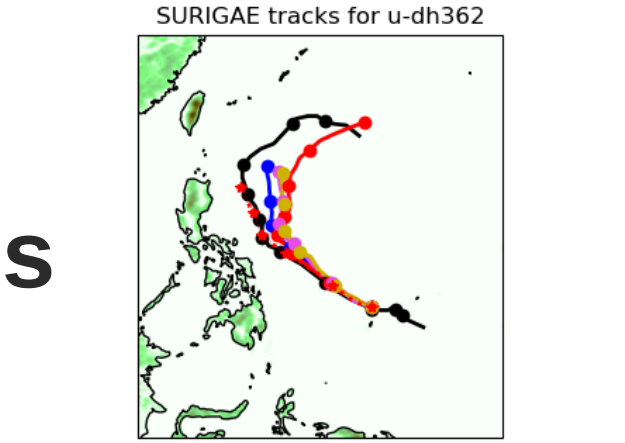

20170123T0800
Radar
11°S
12°S
13°S
130°E
131°E
132°E

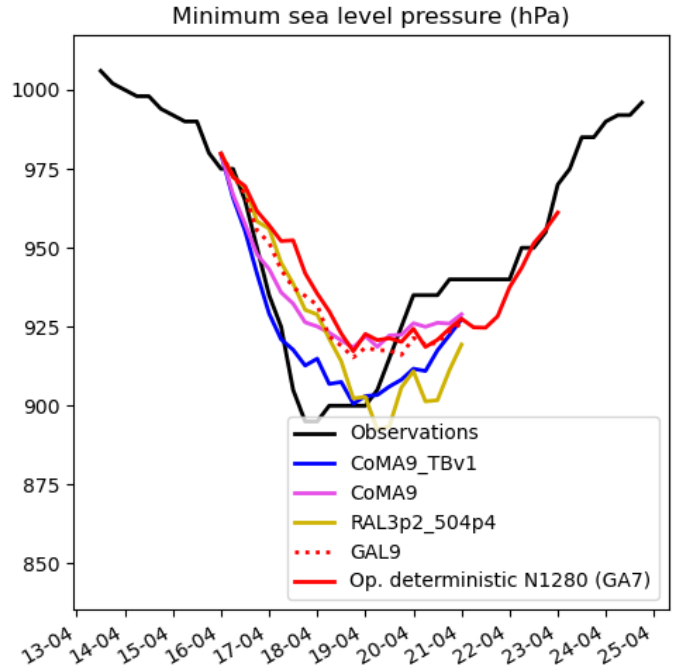

20170123T0800
GPM
11°S
12°S
13°S
130°E
131°E
132°E

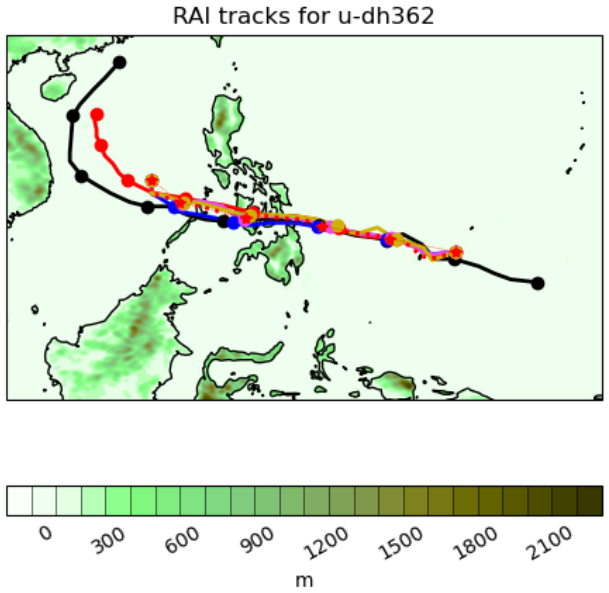

Precipitation amount in 1 hour (radar colours)
ral3_1p5km from 2017/01/23 00Z
2017/01/23 07Z to 2017/01/23 08Z, T+7 to 8
RA3_1p5km
Met Office
1004
0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 32.0
Precipitation amount (mm)
1 2 3 4 5 6 7 8
Total Cloud Fraction (Octas)
Pressure (mean sea level)

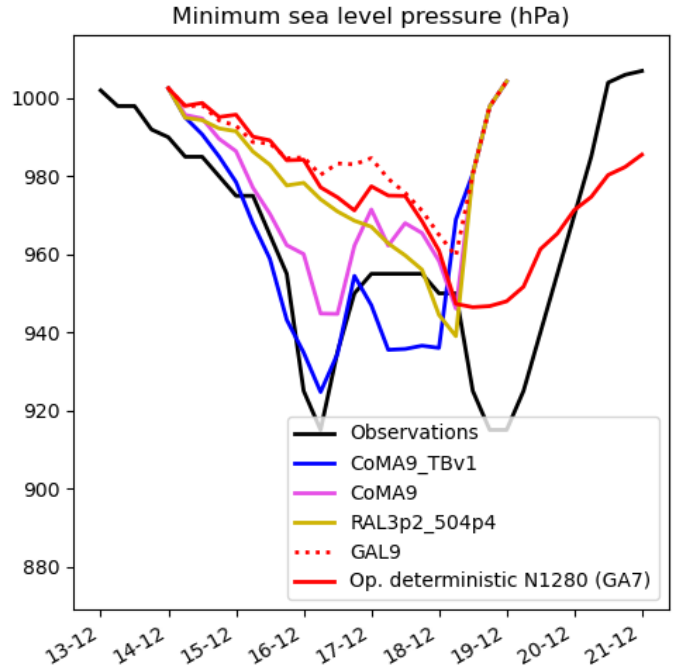
# Tropical cyclone cases

5 km resolution
GA9 driving model



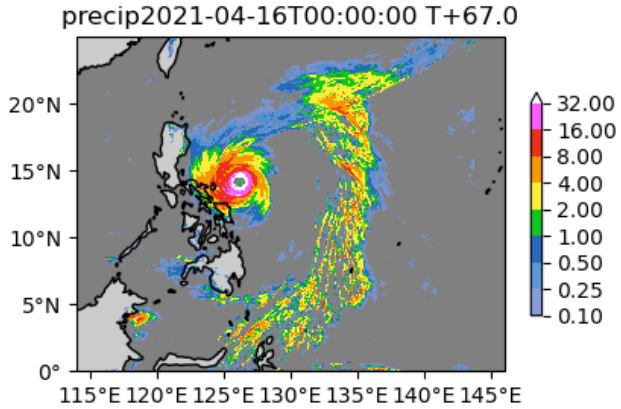



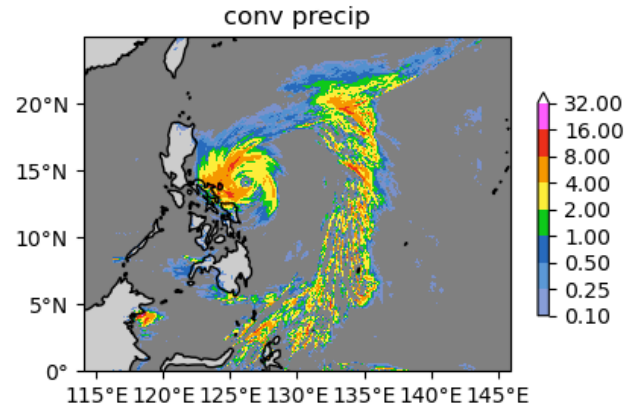
Met Office

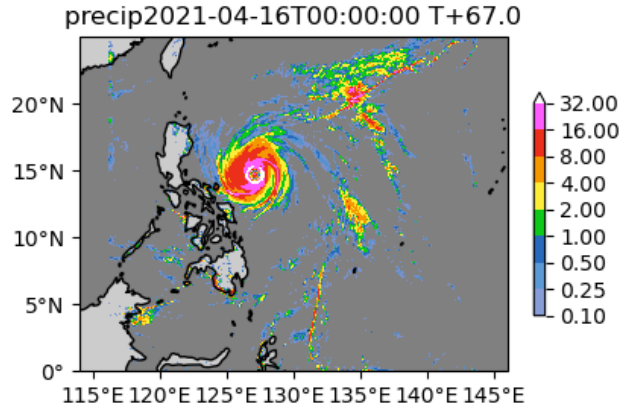
# GAL9

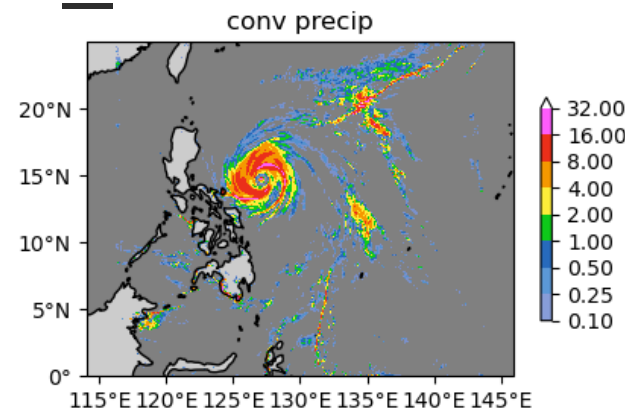
# CoMA9_TBv1

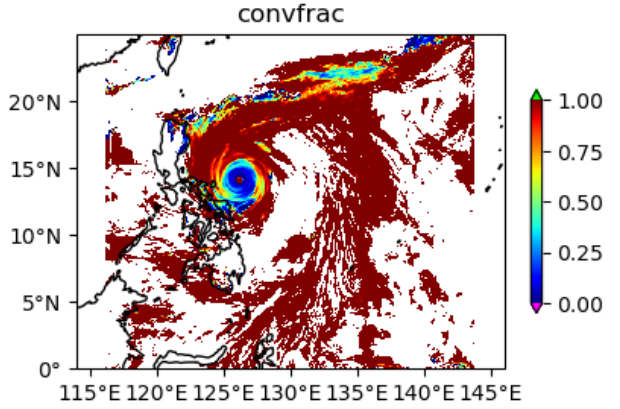
University of Southern

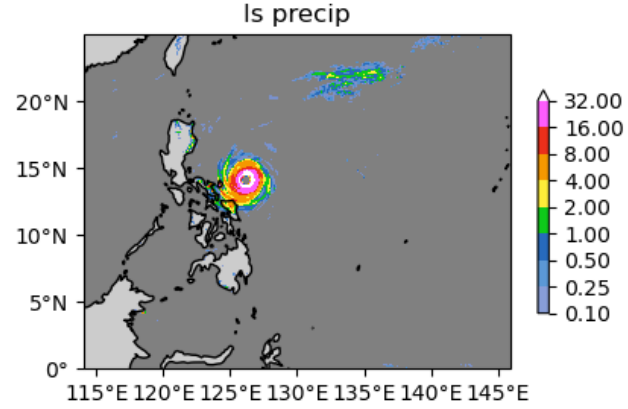


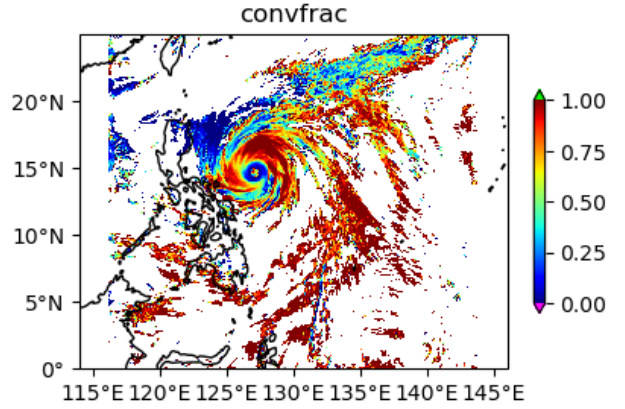



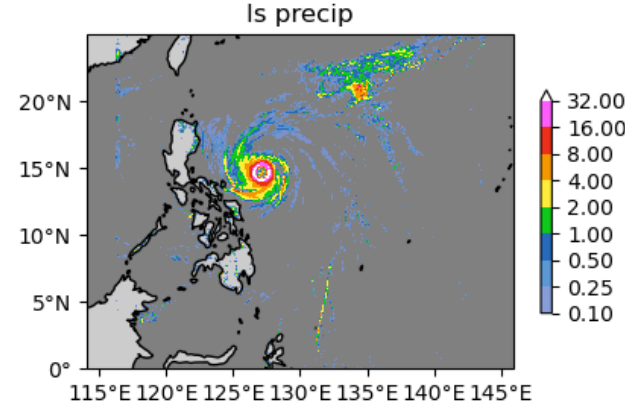



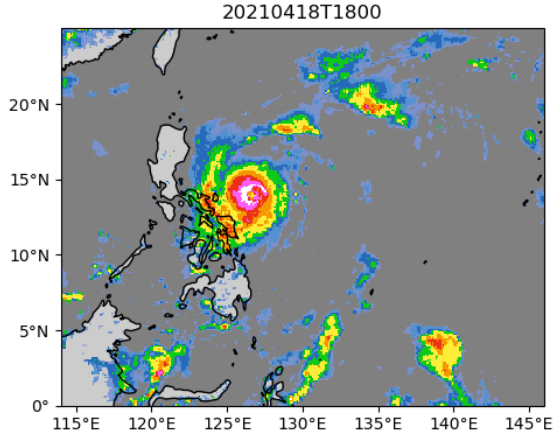



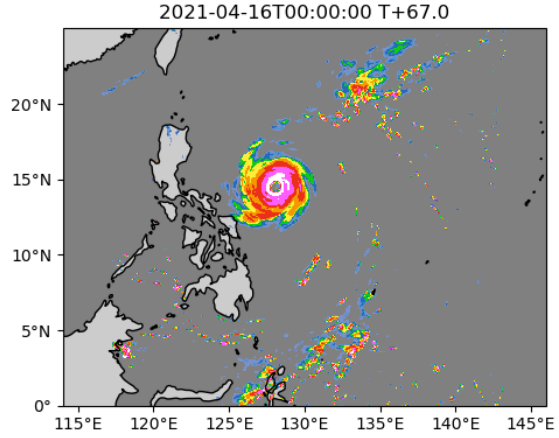




GPM

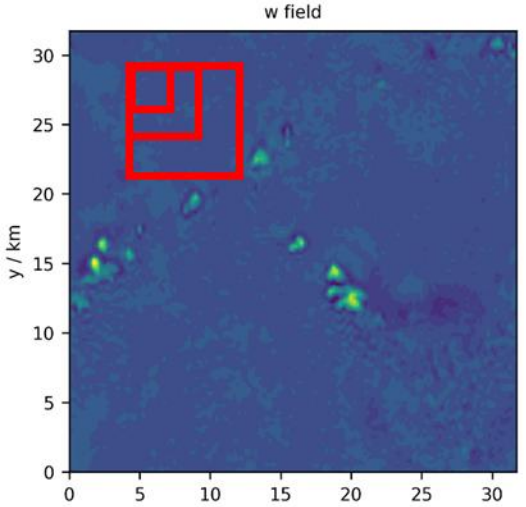


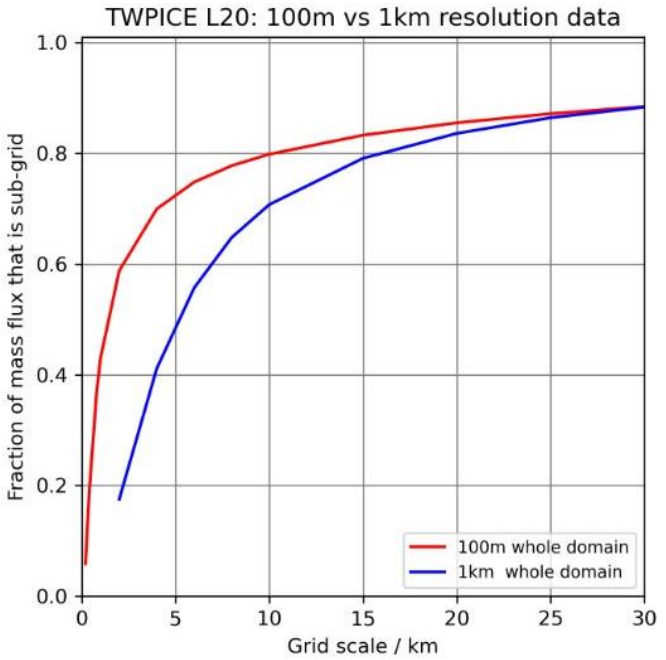




RAL3p2

# Km-Scale CoMorph – next steps

- RMED – K-Scale runs
- Global N2560 NWP
- Idealised evaluation: compare proportions of sub-grid to resolved mass flux as a function of grid-scale used.
- ParaChute
  - Re-derive a functional form for the boundary layer buoyancy and RH perturbations as a function of scale; truncate the perturbations to correspond only to the available sub-grid perturbations (Sam Smith)
  - Further work on length scales with University of Reading
  - Use of convective length scales predictions to modify entrainment formulation.
  - Stochastic treatment of discrete entities.



# CoMorphB update

CoMorph B aims to improve on CoMorph A in several ways:

1) Improve the diurnal cycle / frequency bias of precip over Tropical land (viewed as the main weakness of CoMorph A).
2) Improve applicability to different model-resolutions and contexts by including a dimensionally-consistent model of convective organisation, instead of basing it on an ad-hoc function of grid-mean precip rate.
3) Include more physical processes that were missing / incomplete in CoMorph A (precip-driven downdrafts, cloud-shell downdrafts, dynamic entrainment, triggering of convection by forced uplift…)

The inclusion of many more processes in the convection parameterisation should provide a valuable research tool. The role of the convective-scale processes (e.g. cold-pools, microphysics, etc) in global-scale emergent phenomena (e,g, Monsoons, MJO, etc) can be probed using sensitivity tests where parts of the convection scheme are altered or turned off. Much cheaper and more tractable than trying to understand what's going on in global km-scale models!

**Michael Whitall**

# CoMorphB update

## Diurnal cycle




**CoMorph B appears to give big improvements over A in idealised test cases (better diurnal cycle, convective organisation, cloud evolution…)**

# But….

In global model tests, these improvements seem to come at the cost of degradations to other aspects of model performance (excessive extreme precip events, MJO, mean profiles…)

## Package testing

**CoMorph A.2:** fixes and technical tweaks inside CoMorph under switches
**CoMorph A.bl:** Boundary-layer / turbulence / surface scheme changes
**CoMorph A.cl:** Large-scale cloud and radiation changes
**CoMorph A.pr:** Precipitation and downdraft changes
**CoMorph A.ent:** Parcel radius / entrainment changes
**CoMorph A.gen:** Parcel perturbations and convective triggering changes

University of Southern Queensland

Met Office

# Questions?

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