# Radar Rainfall, Wind, and Hail Analysis and Nowcasting at BoM

**Alain Protat,** Joshua Soderholm, Valentin Louf, Mark Curtis, Jayaram Pudashine, Alan Seed, Carlos Velasco-Forero, Susan Fisher (*BoM*)
Jordan Brook (*University of Queensland*)

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Thanks to Karl Achkar !

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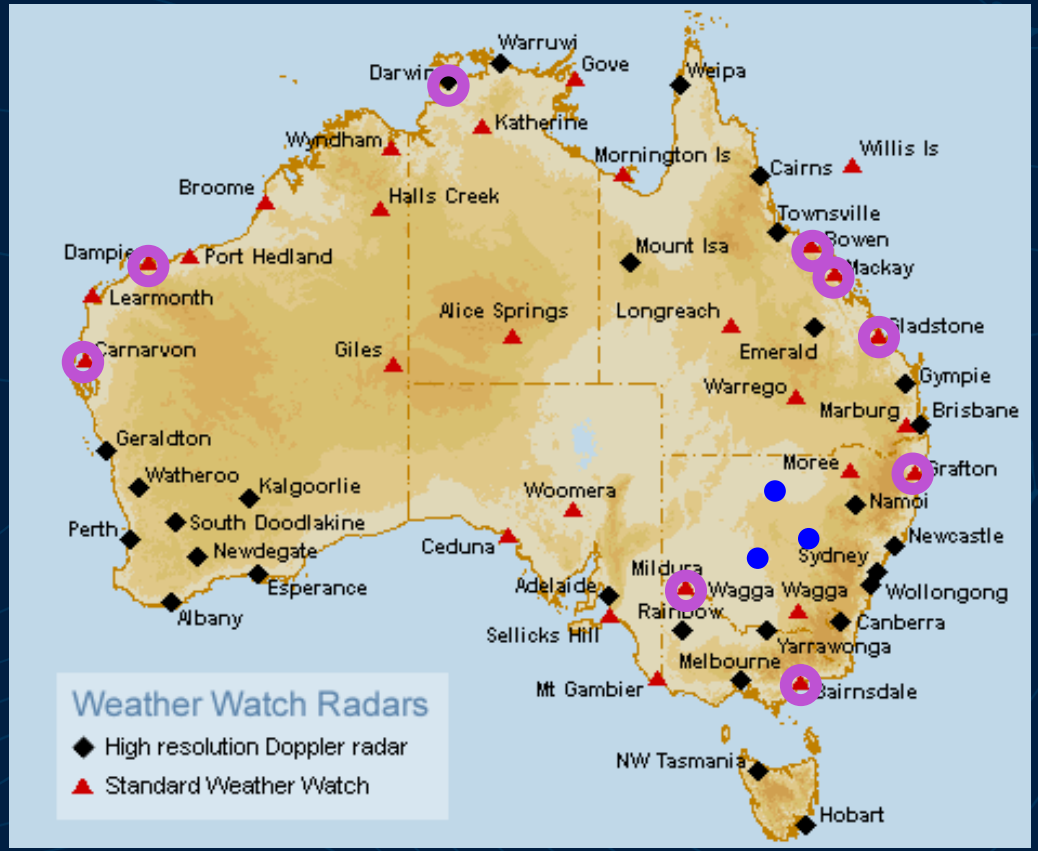
# The (near) future : Increased number of Doppler radars




What Doppler does for you :

- Detect wind-related hazards around populated areas, airports, assets
- Can get Harald's beloved Updraft Helicity !

Radars of the network being upgraded to produce Doppler velocities

Next Doppler upgrades :

- Bairnsdale, Mildura
- Grafton, Gladstone, Mackay, Bowen
- Dampier

New Doppler radars (Oct 2020 – 2021):

- Brewarrina, Hillston, Yeoval (NSW)
- 4 in QLD (inland Townsville to Brisbane)

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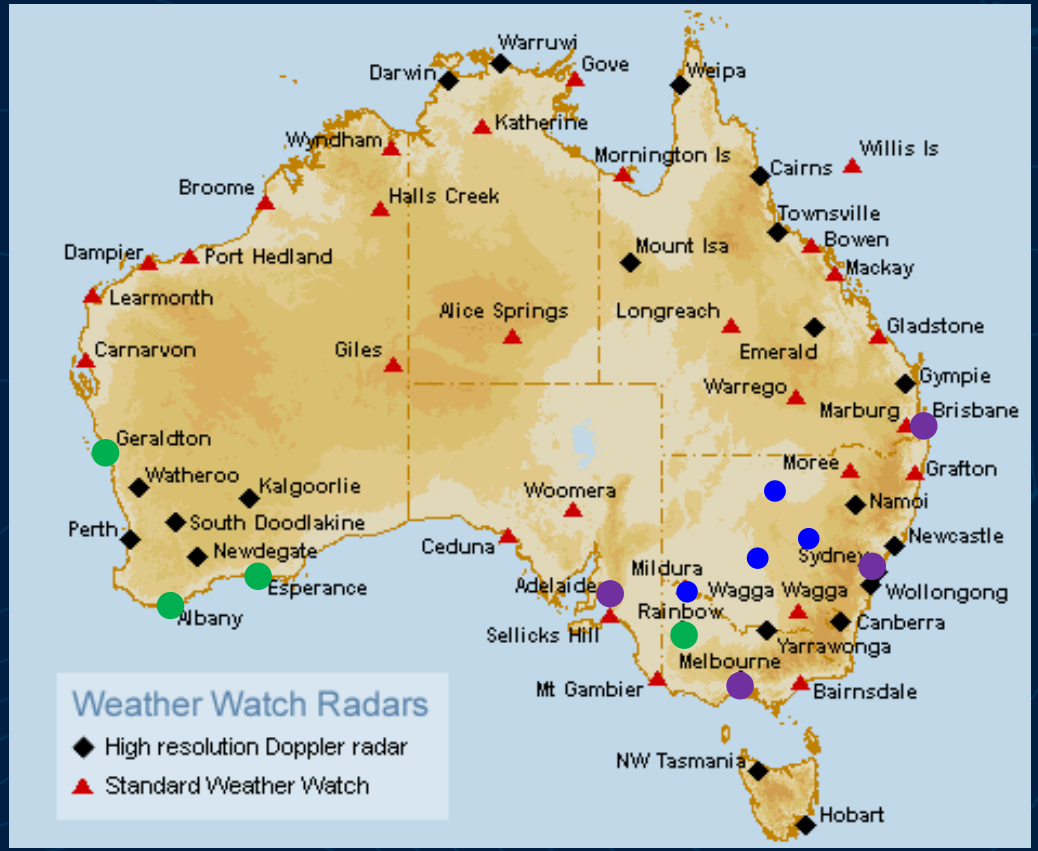
# The (near) future : Increased number of Dual-Pol Radars




What dual-pol does for you :

- Much improved radar data QC
- Improved estimate of high rainfall rates
- Hail and Rain/Hail mixture Detection

S-band dual-pol radar upgrades (2017): ●

- Adelaide, Brisbane, Melbourne, Sydney

New C-band dual-pol radars: ●

- Esperance, Albany, Geraldton (WA)
- Rainbow (VIC)

Next ones (Oct 2020 – 2021): ●

- Brewarrina, Hillston, Yeoval (NSW)
- Mildura (VIC)
- 4 in QLD (inland Townsville to Brisbane)

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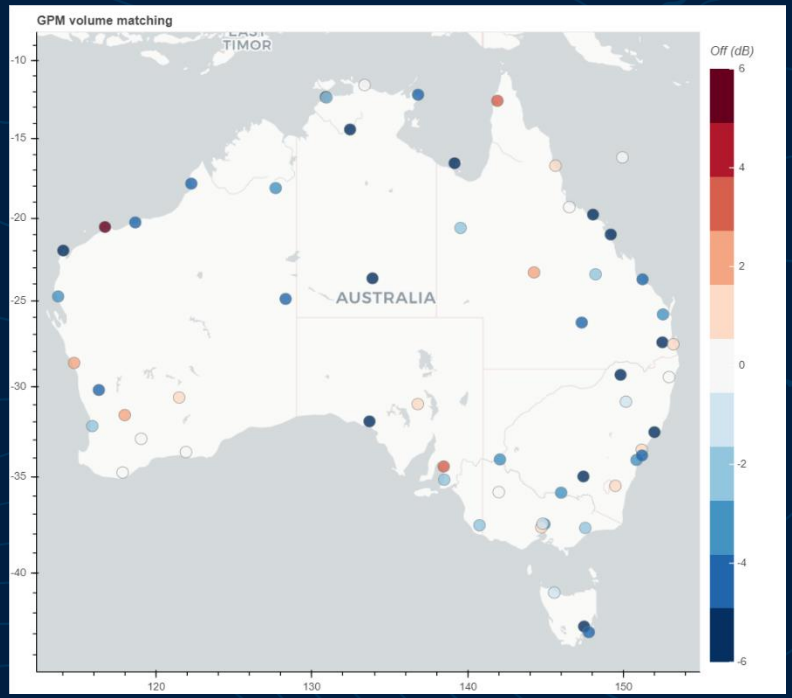
# S³CAR: Satellite Sun Self-consistent Clutter calibration Approach for Radars

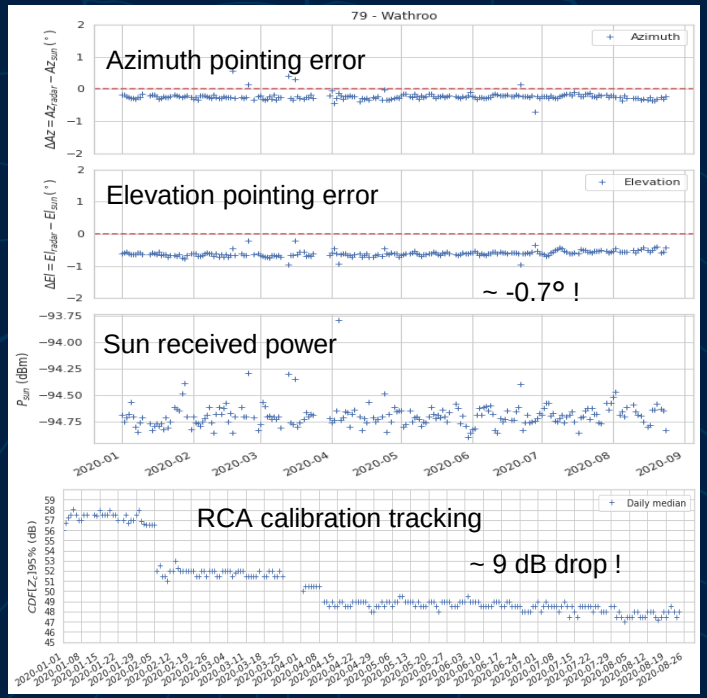
(V. Louf, A. Protat, S. Fisher)

***Accurate calibration of our operational radars underpins all radar-based rainfall and hail services***

**Uses everything we usually throw out (ground clutter and sun interferences) + a spaceborne radar (GPM)**

- Is the radar well-calibrated, and if not, does it come from the transmitting or receiving chain ?
- Is the radar pointing where it is supposed to ?

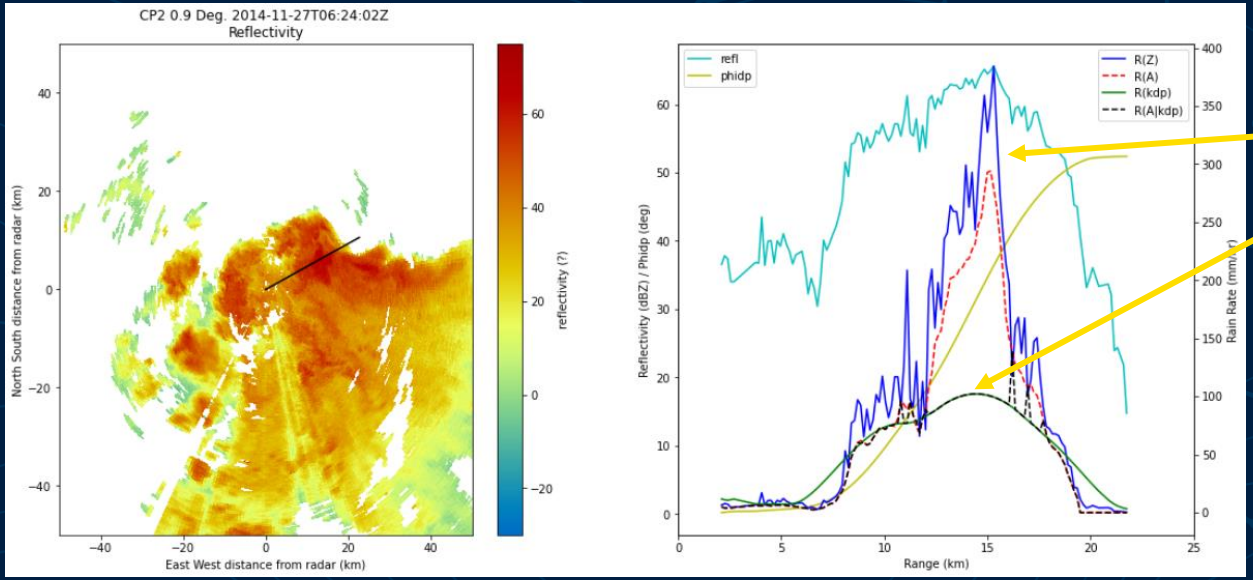


# Improving Rainfall Analysis Using Dual-Pol Radars

(J. Soderholm, A. Protat, M. Curtis , S. Fisher)

Current product: Rainfields-3 (single-pol)
New Product (2021): Rainfields-3 but substitute rainfall where dual-pol adds value
(high rainfall rates, partial beam blocking, rain / hail mixture)




R(Z) ~ 60 mmh$^{-1}$

R(A, KDP) ~ 15 mmh$^{-1}$

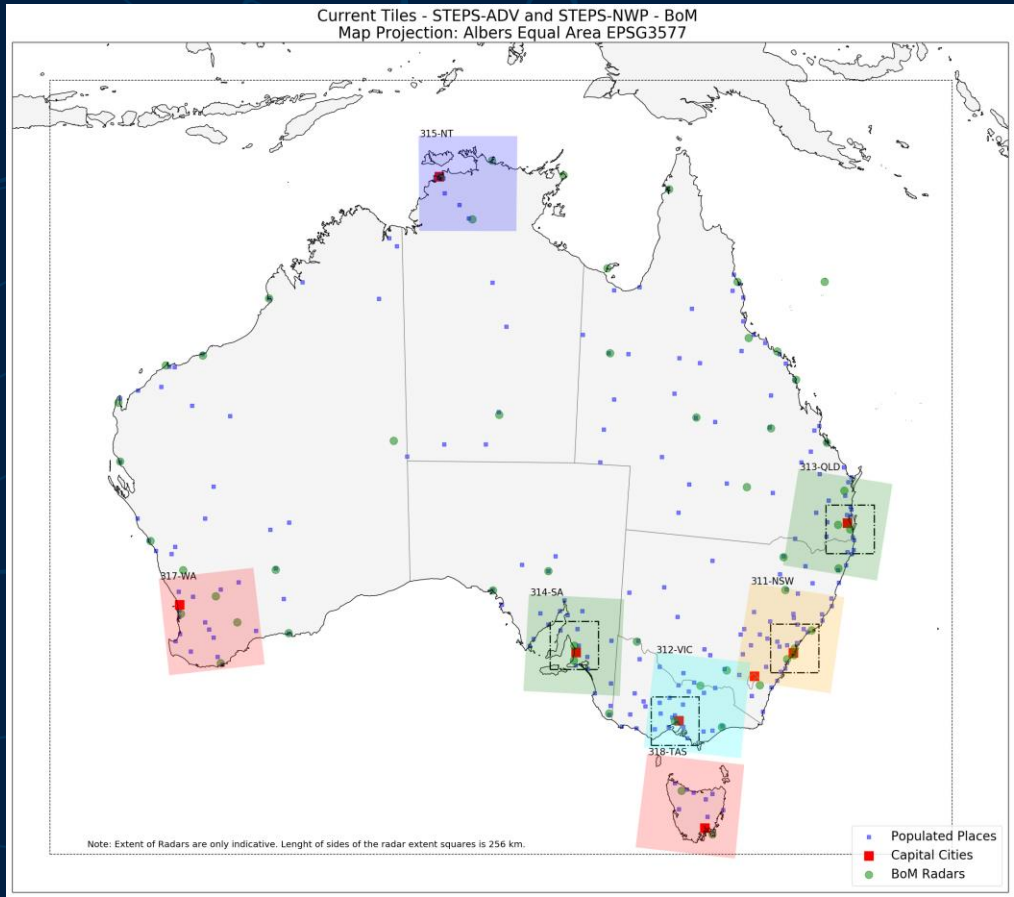
The dual-pol rainfall technique (S and C) has been developed and will be transitioned to operations next year
Based on US/NSSL technique – assumptions still need to be adjusted to Australian rainfall

# STEPS Ensemble Rainfall Nowcasting: Current Products

(A. Seed, C. Velasco, M. Curtis, J. Pudashine)

**Operational**

- 62 operational weather radars
- Radar-only - 4 radars with Nowcast Ensemble Rainfall Predictions up to 90 minutes (every 5 min)
- Radar + ACCESS-C2 : 7 multi-radars domains with Nowcasting Ensemble Rainfall Predictions up to 12 hours (every 10 min)

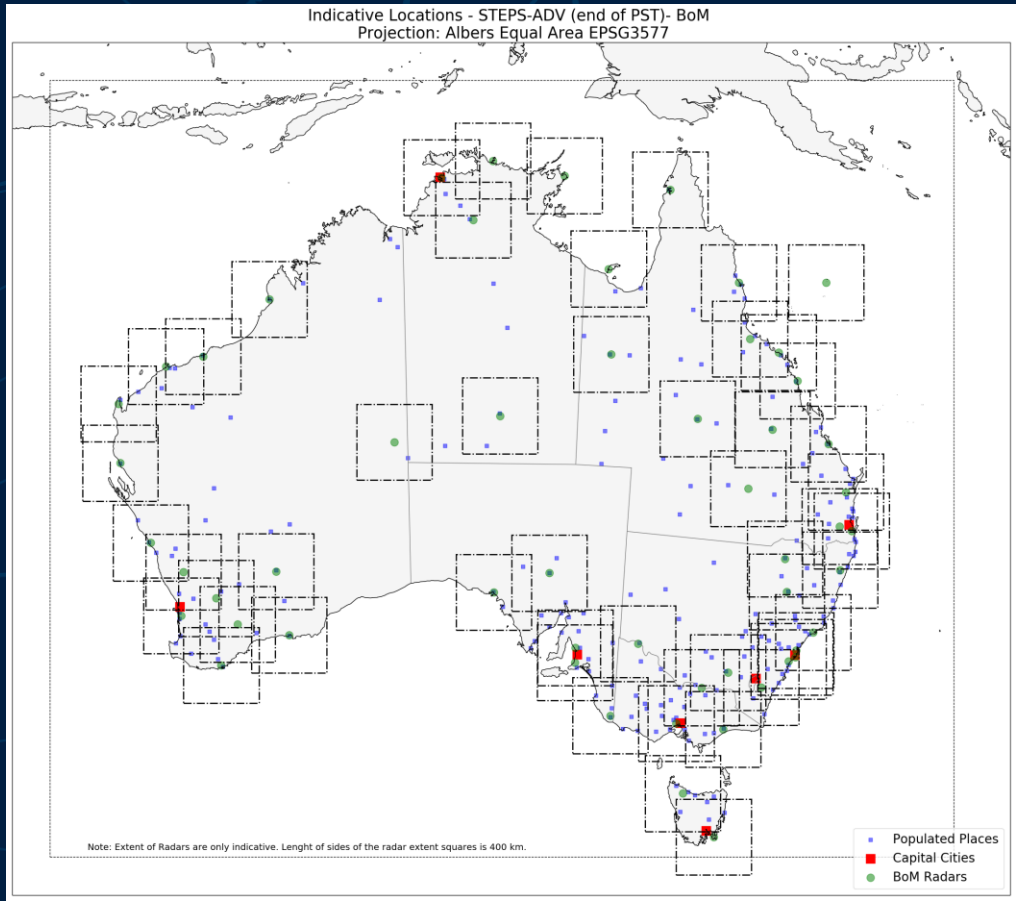


# STEPS Ensemble Rainfall Nowcasting: Future Products

(A. Seed, C. Velasco, M. Curtis, J. Pudashine)

**By June 2022**

- 62 operational weather radars
- Radar-only - **All** radars with Nowcast Ensemble Rainfall Predictions up to 90 minutes (every 5 min)
- Radar + ACCESS-C2 : 7 multi-radars domains with Nowcasting Ensemble Rainfall Predictions up to 12 hours (every 10 min)



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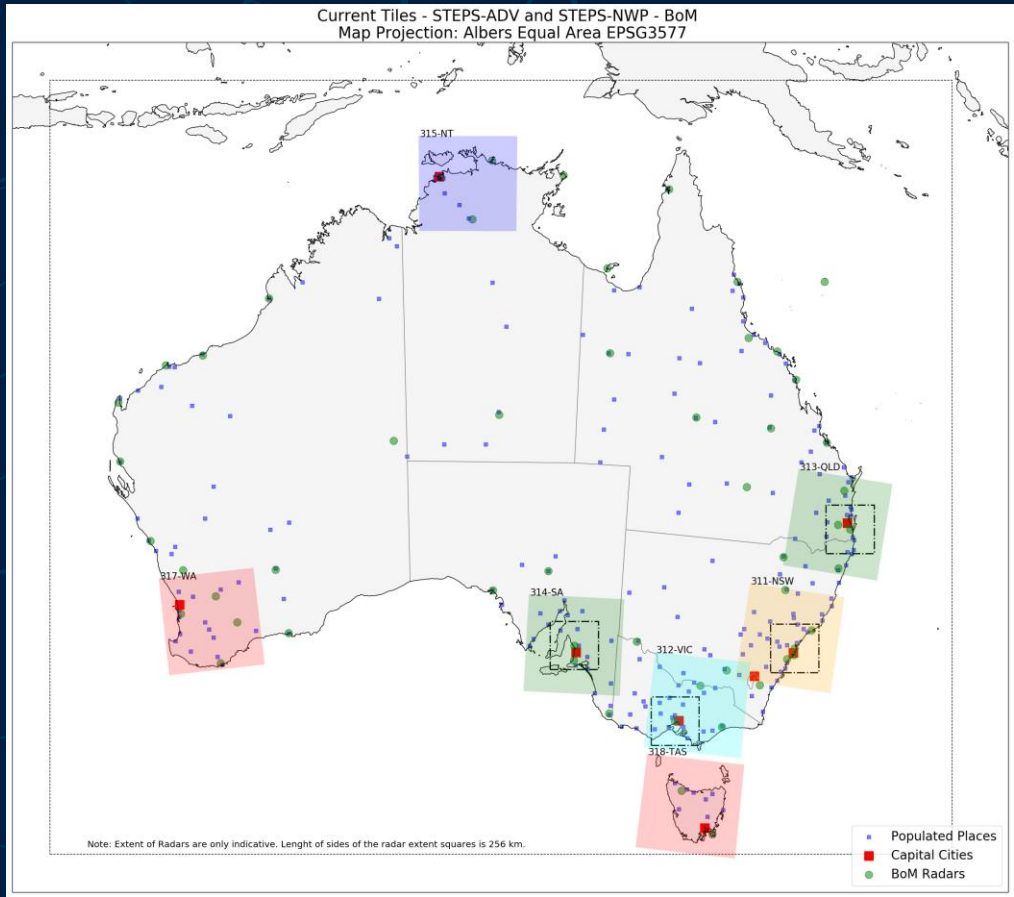

# STEPS Ensemble Rainfall Nowcasting: Future Products

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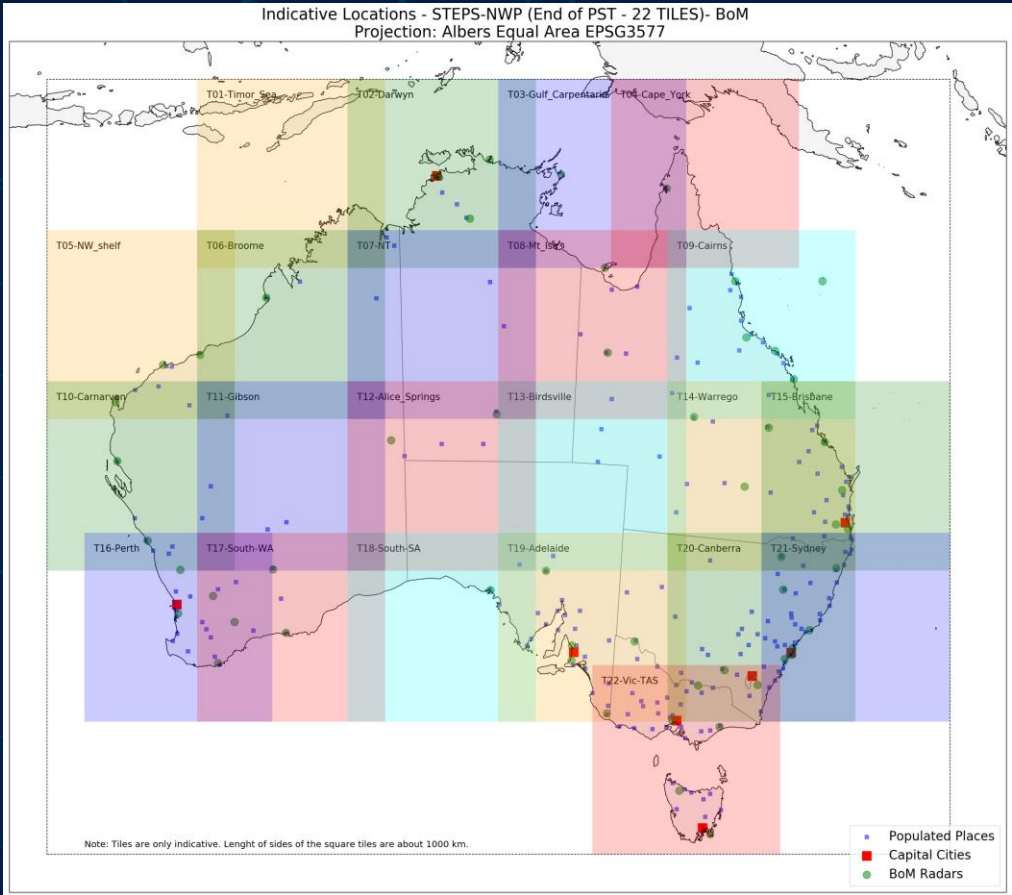
**By June 2022**

- 62 operational weather radars
- Radar-only - All radars with Nowcast Ensemble Rainfall Predictions up to 90 minutes (every 5 min)
- Radar + ACCESS-C2 +ACCESS-G3 : **22 multi-radars domains** with Nowcasting Ensemble Rainfall Predictions up to 12 hours (every 10 min)



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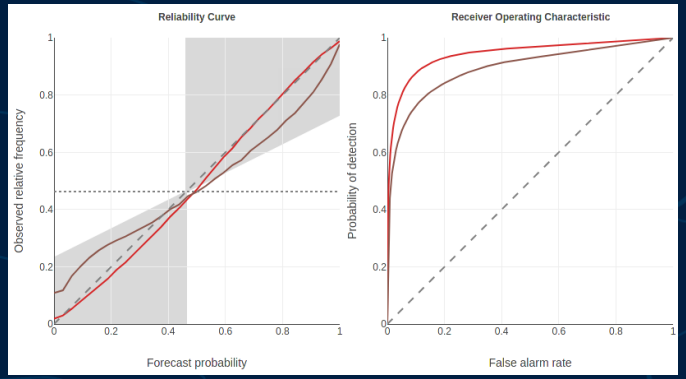
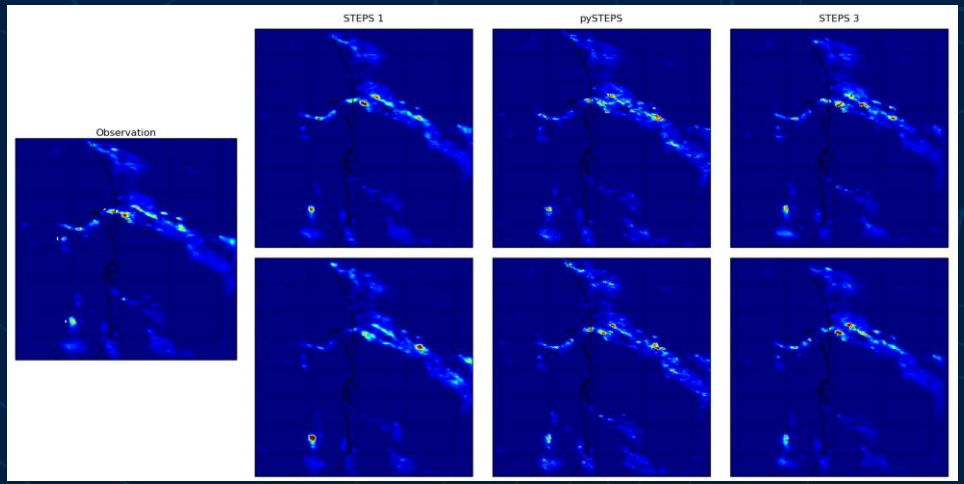
# Rainfall Nowcasting: STEPS 3 Core Development (PST)




STEPS 3
pySTEPS

- "Radar Only" mode complete
- Verification beats STEPS 1 and pySTEPS – 7 case studies
- Better runtime performance:

| Metric | STEPS 1 | pySteps | STEPS 3 |
|---|---|---|---|
| Avg. Runtime | 170s | 76s | 20s |
| Avg. Memory | 1.1GB | 2.6GB | 0.5GB |



# Towards operational 3D wind analysis (nowcasting next year)

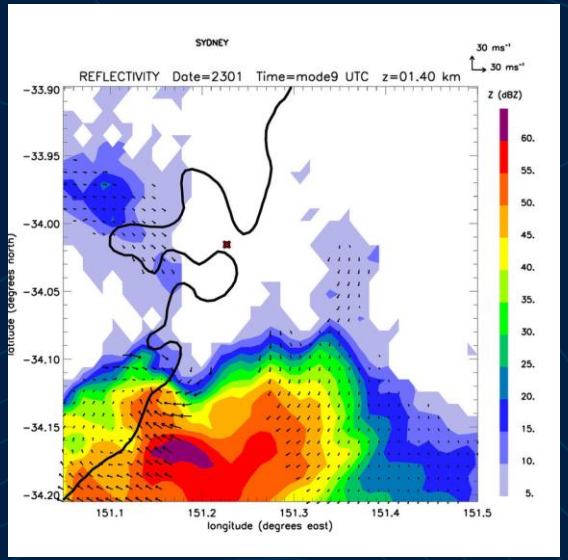
(A. Protat, V. Louf, J. Soderholm)

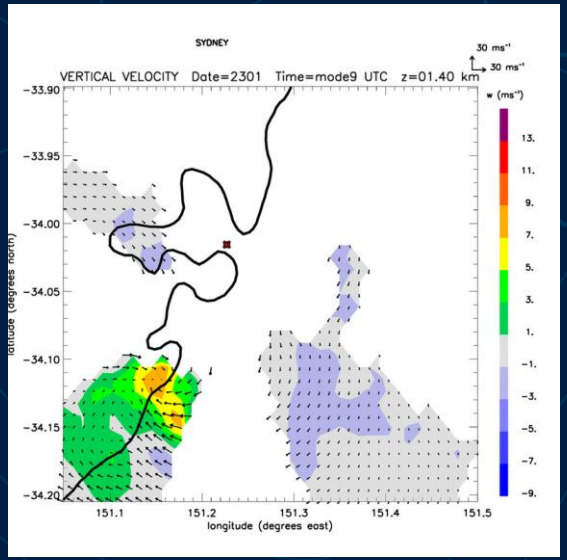
**No service currently !**

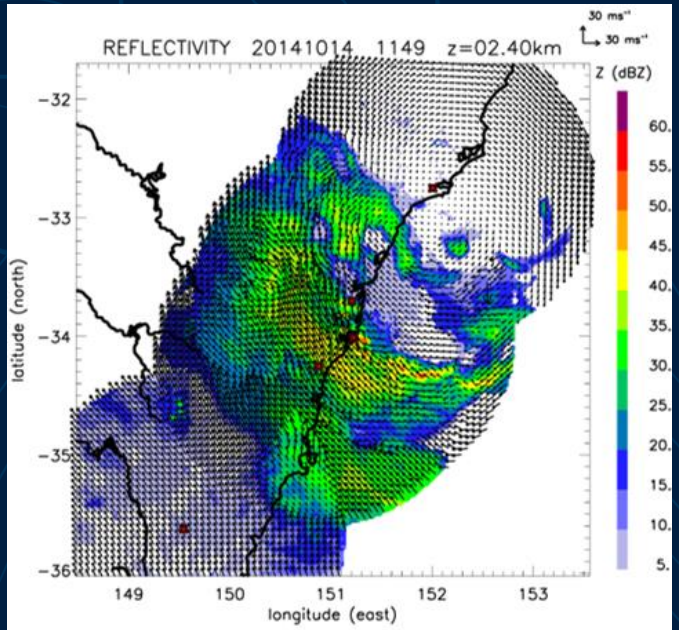
**To get 3D winds you need at least two Doppler measurements at different angles (and you have one equation) or you have to use additional assumptions → multi-Doppler and single-Doppler techniques need to be developed**

**Multi-Doppler 3D wind retrievals only possible over Melbourne and Sydney (dual- or multi- Doppler)**

Typical resolution : 1*1*0.5 km grid size – Code runs in < 1 min for a volumetric scan



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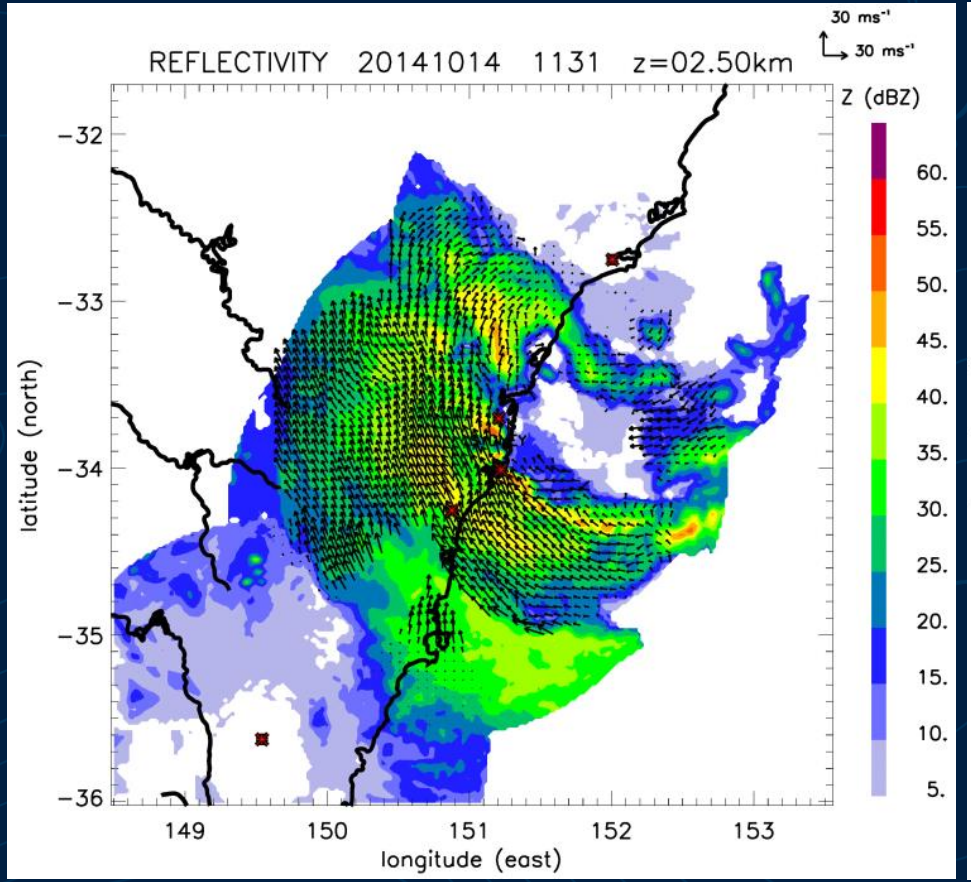
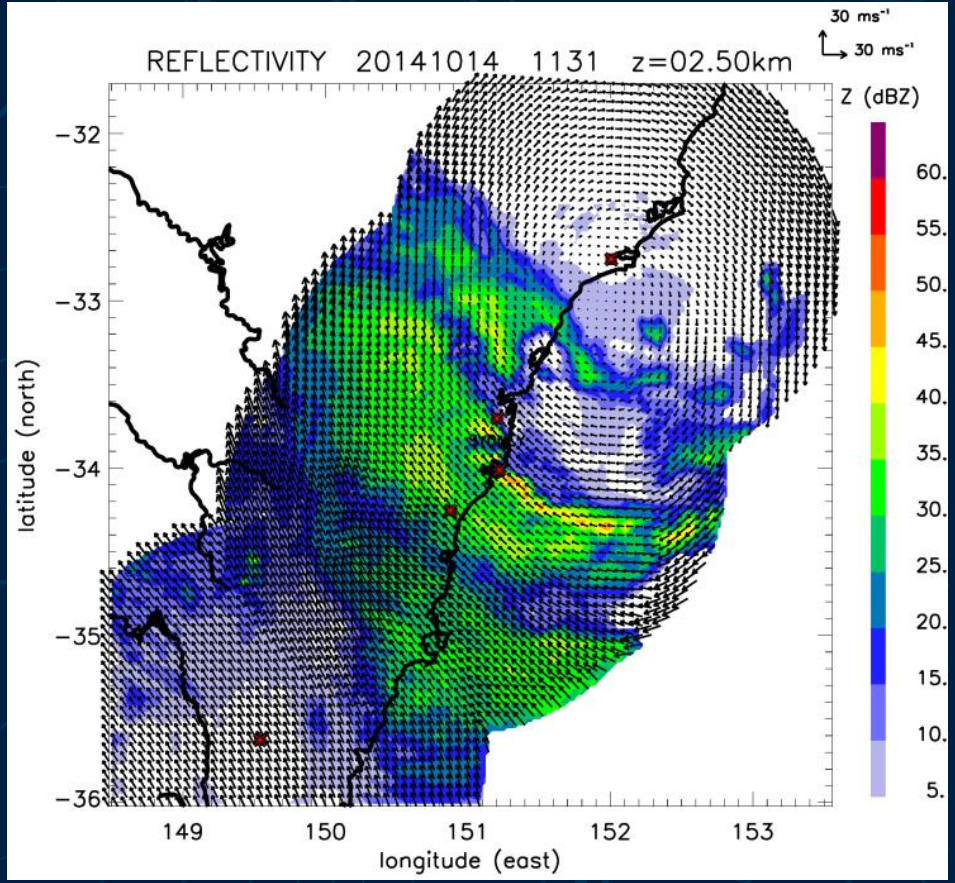
# Multi-Doppler vs DVAD-2radars



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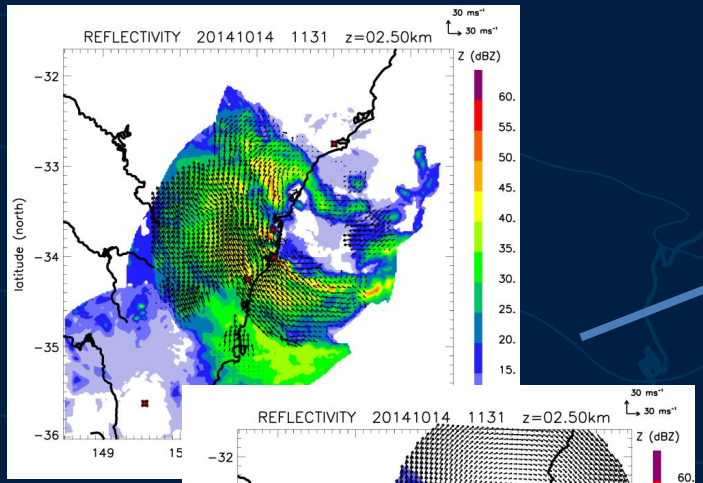
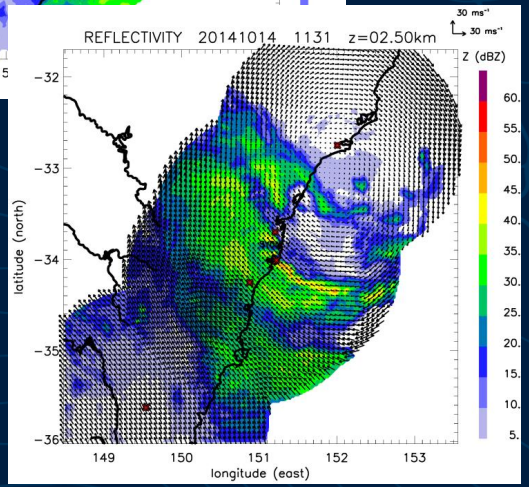
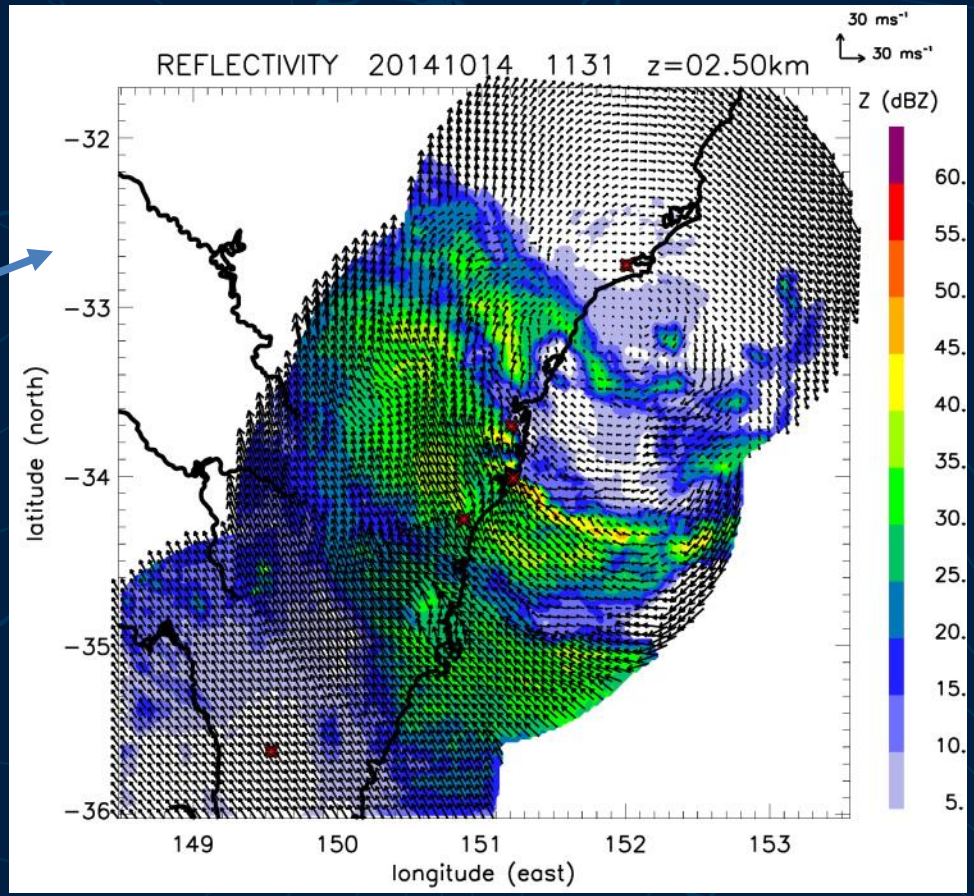
# Final Product : Blending Multi-Doppler and Single-Doppler



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# Hail Analysis and Nowcasting : Current Products

(J. Soderholm, A. Protat, V. Louf)

Current services for situational awareness:

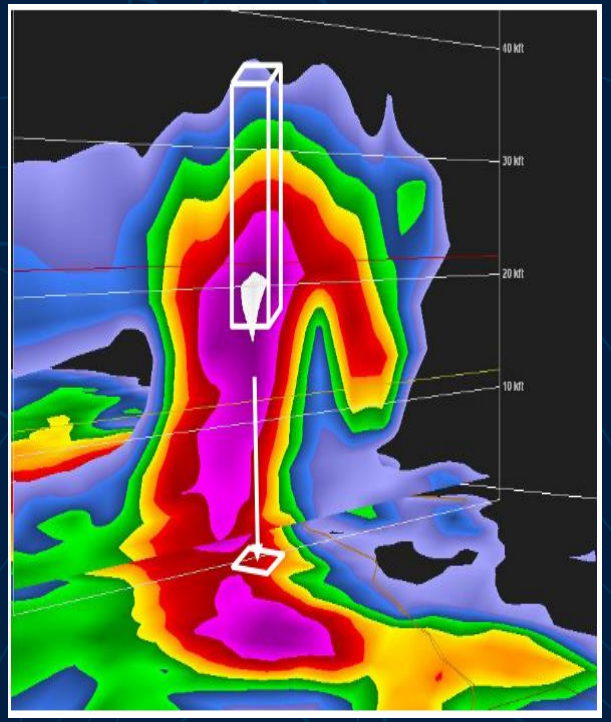
- **Grid-based**: Rainfields 3 instantaneous MESH (size estimate), POSH (probability of severe), SHI (severe hail index). MESH accumulations for last 30, 60 and 90 minutes. Available for site and mosaic domains

- **Cell-based**: WDSS-ii and TITAN maximum MESH, SHI POSH

Main Limitations of MESH : empirical relationship / from data above freezing level / no horizontal advection

**No Hail Nowcasting** : manual extrapolation of cell-based MESH across TITAN forecast tracks to generate warnings

**Our objectives :**
- Improve Hail Size and swath mapping through use of new Doppler and dual-pol capabilities
- Develop Hail Nowcasting service



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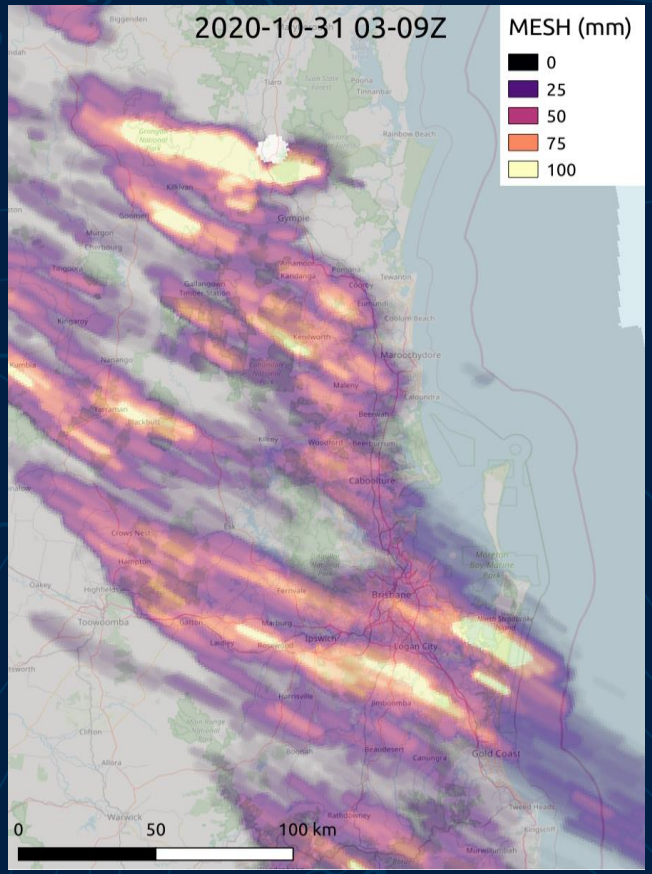
# Hail Analysis : New (single-polarization) product

With support from PERILS we have developed a national mosaic of accumulated MESH, corrected for cell advection, with S$^3$CAR radar calibration ingested

Designed to support hail impact mapping and verification

This research prototype has been shared with 8 private companies (insurance, reinsurance, and energy) to raise awareness and receive feedbacks.

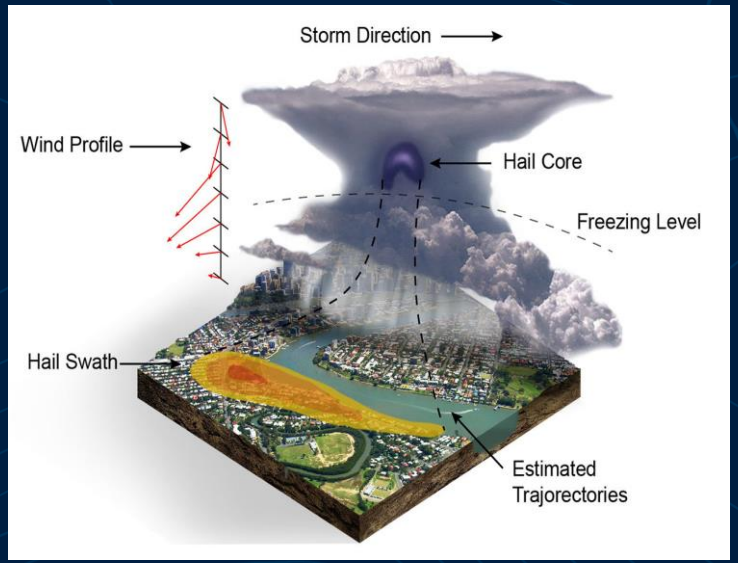


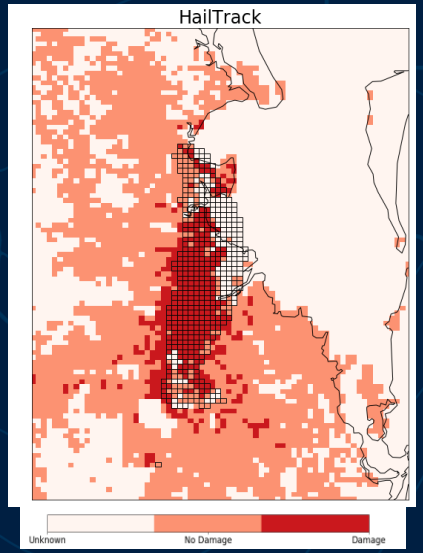
# Towards Hail nowcasting : HailTrack (J. Brook, UQ PhD student)

Single / Dual-Doppler 3D winds + Single / Dual-polarization Hail Detection aloft + Single / Dual-polarization Hail Size aloft

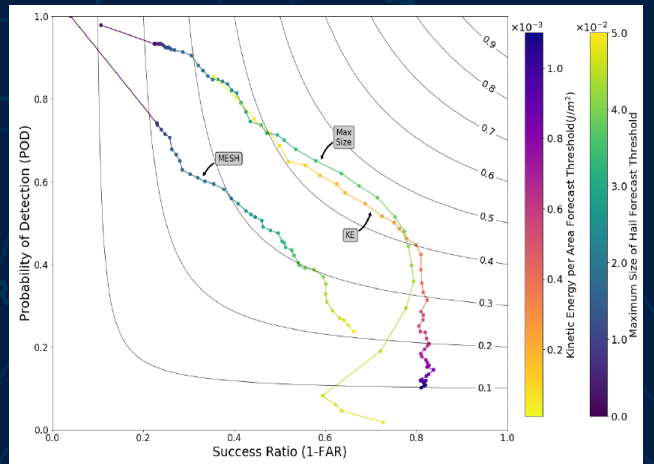
PST Project P21

**Nowcasting : where and when hail is going to reach ground soon**




Insurance claims




| Type | Threshold | POD | FAR | CSI | HSS |
|---|---|---|---|---|---|
| HailTrack Size | 3.8 (cm) | 0.59 | 0.33 | 0.46 | 0.61 |
| HailTrack KE | 0.00019 (J/m$^2$) | 0.59 | 0.38 | 0.44 | 0.59 |
| MESH | 3.2 (cm) | 0.48 | 0.5 | 0.32 | 0.46 |

# Thanks

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