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Data Assimilation for the Bureau's Operational Systems: Aims and Challenges

Peter Steinle, Bureau of Meteorology

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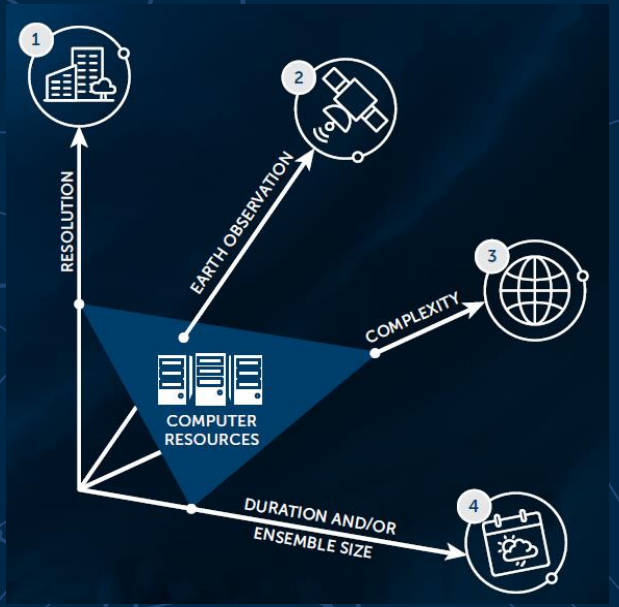
Context

- R&D Plan for 2020-2030
- Better rapid update, km-scale DA (clouds, PBL etc.)
- Pathway to Coupled DA
- Pathway to Urban Scale
- Atmospheric DA requires
  - wide range of scales to be initialized: 4D Var + Ensembles
  - More satellites, radar etc.
- Evolving environment
  - Changes in models (UM → LFRic, MORUSES, …)
  - New HPC architecture
  - New sources of observations



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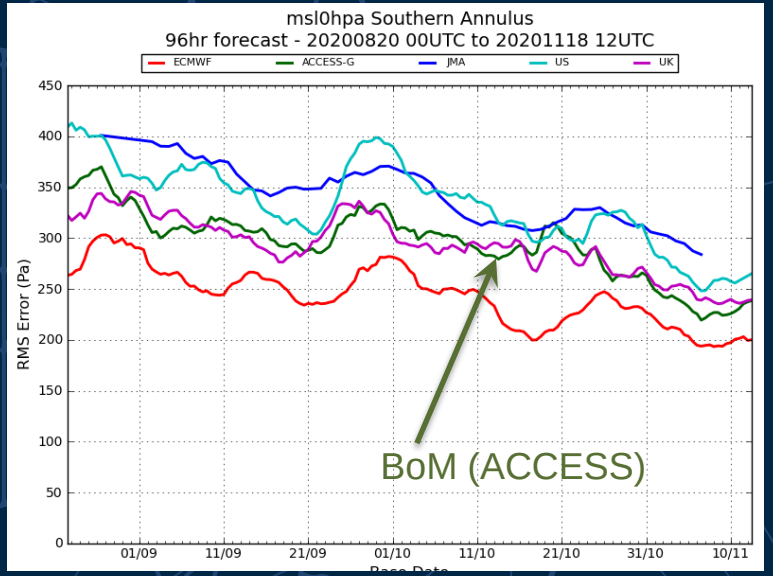
Where are we now?

- Global NWP (12km/30km):
  - Hybrid 4DVar
- km-scale NWP (1.5km/2.2km):
  - 4D-Var + Latent Heat Nudging (& radar reflectivity)
- Land Surface: EKF for soil temperature & moisture
- Ocean: EnKF-C
- Sea Ice: Nil
- Ocean Waves: Nil
- Network Design / Value of Observations: FSOI



96hr RMS Forecast Error, MSLP 60°S-20°S
(lower is better)

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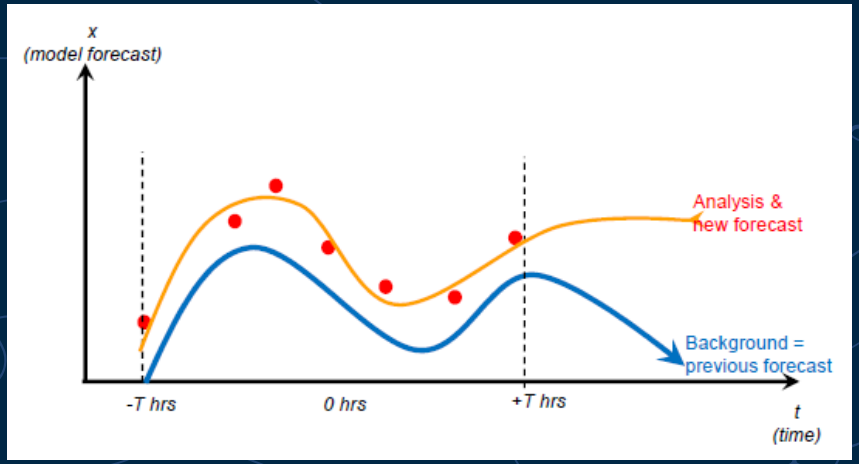
4DVar



Compare obs & background

- Adjoint model maps obs differences back to initial state
- Perturb initial condition & forecast , given known error characteristics
- Repeat

Linear Perturbation Model & Adjoint link time

- Very simple for UM (no convection etc.)
- Defines analysis variables (total moisture)

Background error covariance fill the gap between obs

- Need ensemble info as vary in space, time & shape
- But ensemble is very small

→ use $\mathbf{B_c}$ (climatological)

Ensemble just provides local modifications

= Hybrid VAR

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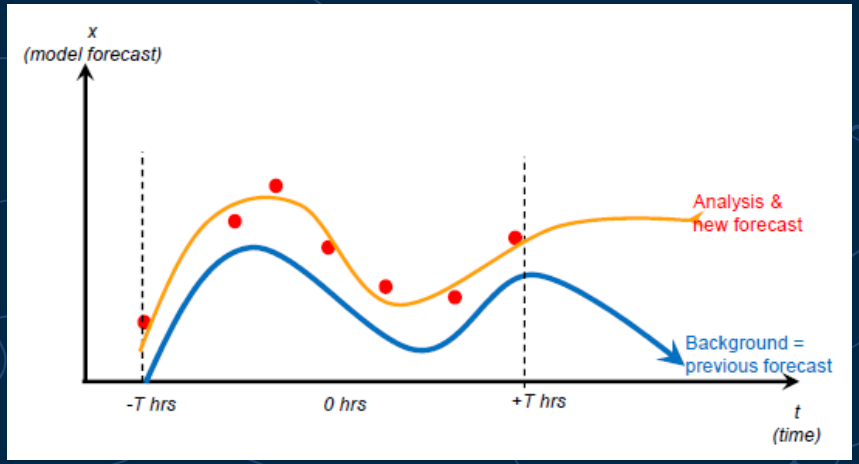
4DVar & ensembles



Two Options

EnVar :

- use non-linear solutions (ensemble)
- Increments from $\boldsymbol{B_c}$ ***do not*** evolve

Hybrid Var :

- Linear perturbation model
- Increments from $\boldsymbol{B_c}$ ***does*** evolve

Use Ensemble Linear Perturbation Models to updating all variables
Coupled systems
Other highly non-linear systems, e.g. urban

Poster: Nathan Eizenberg & Craig Bishop

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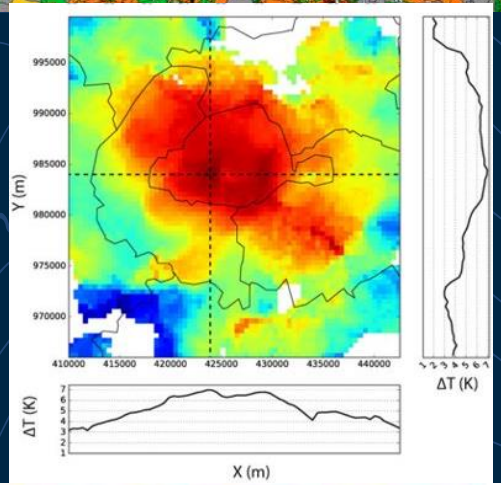
Urban, *O(100m)* : Observing the urban landscape

- Standard in situ observing system :
  - siting standards not appropriate
- Remote sensing :
  - Lowest level
  - footprint, safety issues, cost ?
- 3rd party data :
  - Drones, Phones & Automobiles,++
  - Coverage & cost good
  - Accessing data ?
  - Obs Quality & Observation Operator
    - Possible application for AI/ML



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Land Surface

- Currently soil temperature & moisture updated
  - JULES
  - Australian Water Resources Assessment (AWRA)

- Vegetation activity (→ evapotranspiration) & land surface (skin) temperature

  - Effect of major fires on local conditions
  - Crop greenness

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More complexity = More work

- Collaboration essential
  → Joint Environment for Data assimilation Infrastructure (JEDI)
  Combined effort across major US (and now UK) centres

- Require new tools & new skills

- Essential to stay up-to-date
  - Local developments need to be relative to latest code
  - Ease of integration from Bureau back to source code trunk
  - Software environment must support synchronized coding & testing

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Where to?
More observations, used better

Next Few Years – introduce new infrastructure & science

- Better accounting for non-linearity : EnVar, LETLM etc.
- Greater Collaboration: JEDI
- Vegetation in land surface models

Longer Term – start applying to new systems

- Fully Coupled DA
  - *ensemble based DA with better linear model*
- Urban
  - as above *plus* 3rd party observations (*likely require AI/ML)*

- ❖ *On top of the usual: satellites, radars & more satellites*
- ❖ *Added importance of a high quality ensemble system*
- ❖ *New skills, including AI/ML*
- ❖ *HPC environment suitable for collaboration*