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IR satellites – current NWP impact and future considerations

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Model configurations

	Global (ACCESS-G3 and GE3)	City (ACCESS-C3 and CE3)	Tropical Cyclone (ACCESS-TC3)
Deterministic	N1024 (12 km), L70 00, 06, 12, 18 UTC	1.5 km, L80 6 domains Hourly	4 km, L80, Up to 3 relocatable domains 00, 12 UTC
Ensemble	N400 (36 km), L70 18 members (plus lagging) 00, 06, 12, 18 UTC	2.2 km, L80 12 members (plus lagging) 00, 06, 12, 18 UTC*	
Data assimilation	T-3 :T+3 window Hybrid 4D-Var (N144 + N320)	C3: Hourly cycling 4D-Var	T-3:T+2 window 4D-Var
Bias Correction	VarBC, with static scan bias correction	Uses VarBC coefficients from G3	Uses VarBC coefficients from G3
SST analysis	GAMSSA[1]	RAMSSA[2]	GAMSSA[1]
Soil moisture analysis	EKF analysis of screen temperature & humidity and ASCAT soil moisture	Uses Soil moisture analysis from G3	Uses Soil moisture analysis from G3

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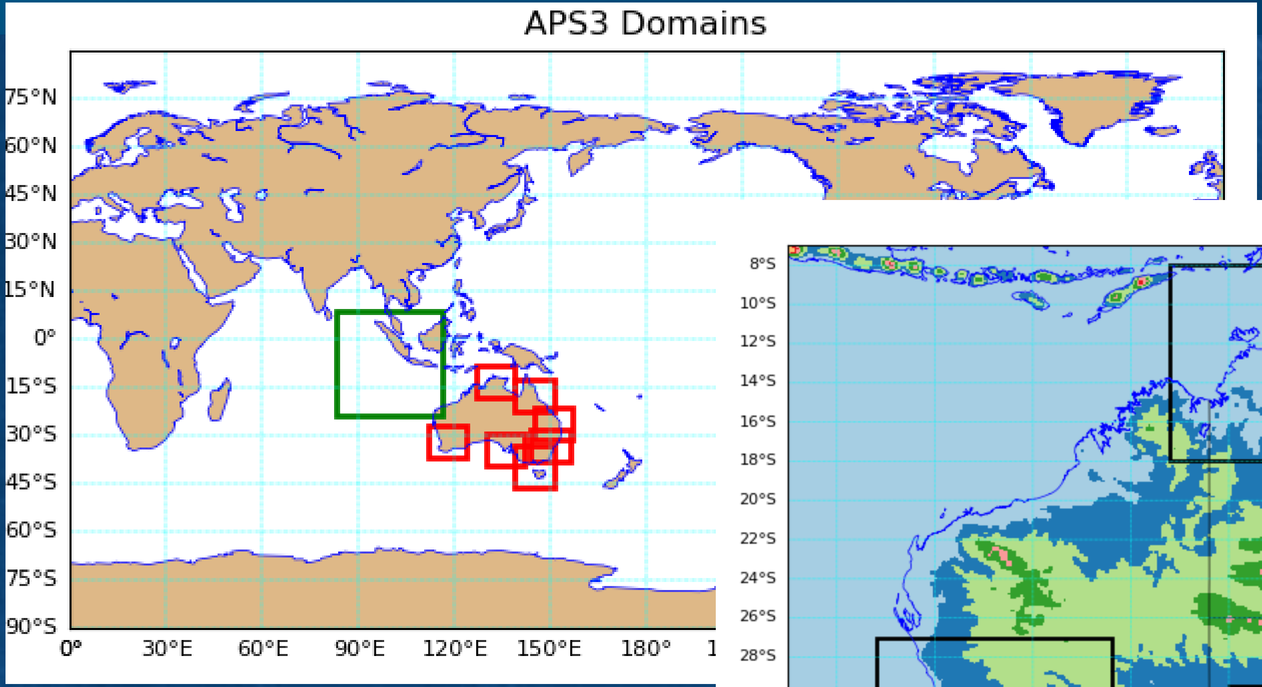
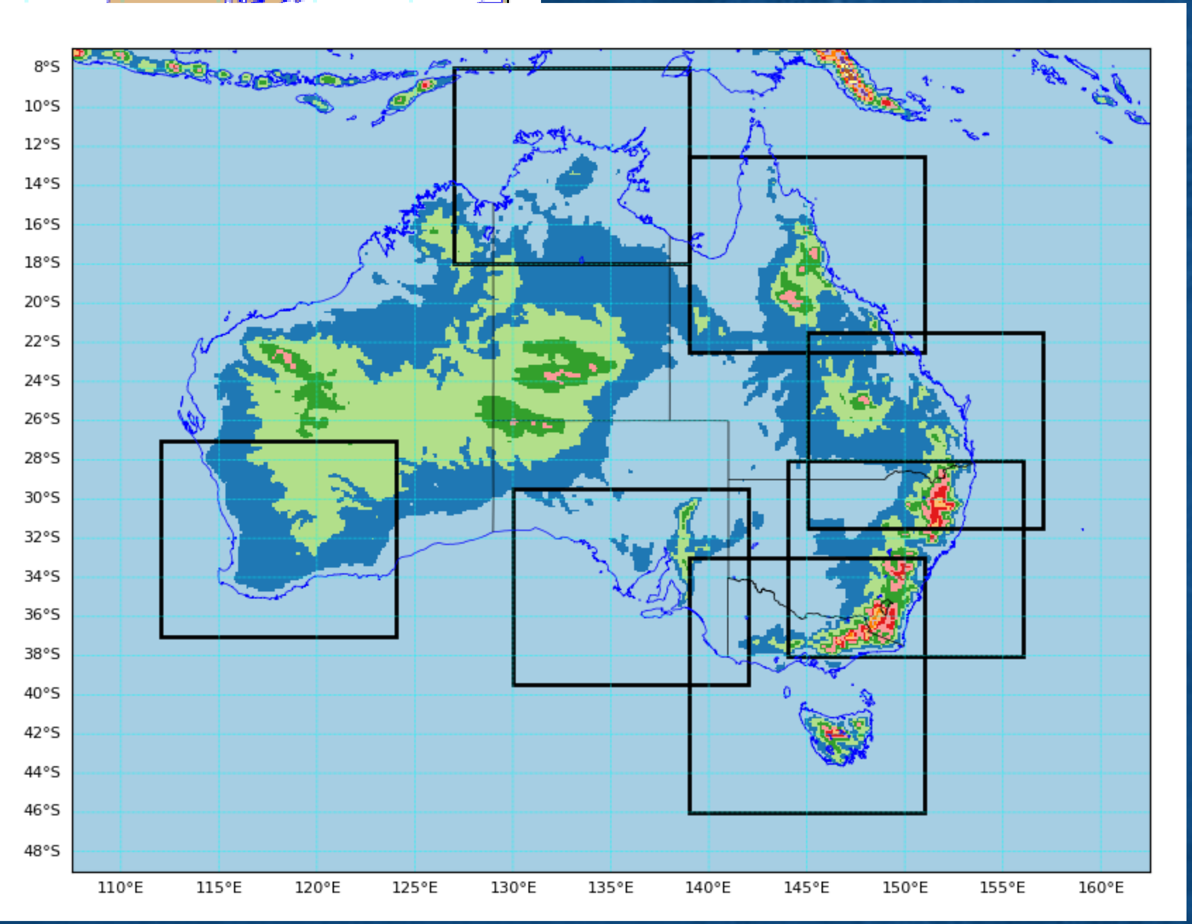
ACCESS NWP "APS3" Systems (operational since 2019)





ACCESS-G3 (12 km) and GE3 (36 km)

ACCESS-TC3 (4 km): up to 3 relocatable domains

ACCESS-C3 (1.5 km) and CE3 (2.2 km): 7 domains

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Observation usage

Type	Instrumentation	Comment
Radiance	AHI CSR AIRS AMSR-2 ATMS (S-NPP, NOAA-20) – Global, Local AMSU-A/MHS (Metop-B,C, NOAA-15,18,19) – Global, DBNet, Local CrIS (S-NPP, NOAA-20) – Global, Local IASI (Metop-B,C) – Global, Local SSMI/S	G3 only G3 only G3 only
GNSS	GNSS-RO (TerraSAR-X, Metop-B,C, FY3-C,D) Ground-based integrated WV	G3 only Australian stations only
AMV	AHI (JMA Winds and local winds) GOES-16,17 Meteosat-8,11 MODIS	10-min winds in C3
Surface winds	ASCAT (Metop-B,C)	Coastal winds in C3
Aircraft	AIREPS, AMDAR	
Surface	BUOY, METAR, SHIP, SYNOP (BUFR where available) TC BOGUS	 G3 and TC3 only
Sonde	PILOT, TEMP, WINPRO, BUFR Sonde where available	
Radar	Doppler Radar Winds	C3 only

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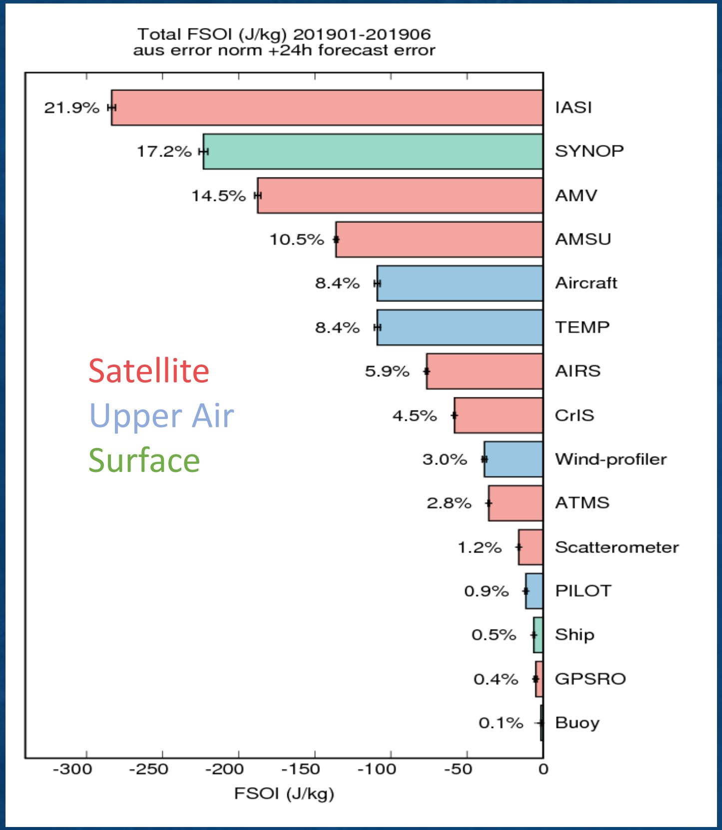
FSO observing systems impact

Australian Region +24 hour forecast error norm



Total 6-month FSO impact per observing system

- Unfortunately, old results
- IASI dominates forecast skill in our system
- Note we are not using AIRS at the moment
- Note this slide is prior to use of NOAA-20; expect CrIS impact to be greater in 2021

Responses to SAT guidance memo

- Many of the comments in this presentation are in relation to the
  - Guidance Memo for Hyperspectral IR sounders written by the SAT team
- I've tried to keep the points general though
- It's not clear whether the memo is about the 'backbone'/'core' sounder capability or additional instruments in a smallsat constellation
  - In general, the Tier 1 proposal seems unambitious relative to current instruments
  - But if that will be mitigated by a constellation/rapid repeat, a lower specification instrument would probably still be useful.

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Spectral, Radiometric and Spatial considerations

- These aspects of an instrument create a trade-off space. A perfect instrument would have
  - High spectral resolution, able to resolve absorption lines of chemical constituents free from contamination
  - Incredible radiometric accuracy and stability
  - A small footprint, commensurate with the vertical resolution of the instrument
- You can’t consider these items separately, although minimum performance requirements for each can be set
- The requirements for GEO and LEO instruments are clearly related, but are possibly prioritised differently.
- Consider NEdT, footprint size and spectral resolution to be hygiene factors.
  - Set a minimum requirement for each
  - then consider the trade-offs separately for each platform and target application
  - then build the best instrument you can for the price

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LEO considerations

- LW vs SW argument is pertinent here as the instrument may be small
  - It is acknowledged that NWP centres have little experience of using the short-wave channels
    - More problematic RT (e.g. sun-glint, non-LTE)
    - Detectors are less sensitive so generally higher-noise
    - Cloud detection may be trickier
    - Errors are more highly correlated
  - Tier 3 (no MW band) is not really considered desirable even for temperature sounding
- Chemistry applications
  - Require LW band and LW end of the MW band (don't avoid the methane!)
  - High spectral resolution benefits chemistry more than NWP
- Short dwell-time limits the spatial resolution – noise performance trade-off space
  - Too high a spatial resolution may result in an unacceptable noise performance
  - In general, a low-noise instrument is preferable for NWP
- Consider IASI or CrIS to be a baseline instrument, not a stretch-target
- IASI and CrIS are great for NWP
- Spectral and radiometric performance may be somewhat mitigated by a constellation but this is hard to quantify

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GEO considerations

- The requirement for full-disk will also limit the dwell time
- Smaller pixels are generally preferable in a GEO instrument, but we do not yet have experience of GEO sounders
  - Applications such as
    - generation of AMVs via emerging science
    - cloud characterisation
    - delivery of information in rapidly developing weather situations like TC
- Might there be future applications such as
  - bush-fire characterisation and smoke detection?
  - air quality event detection and impacts for particular chemical species

- In general, we would prefer a smaller footprint at the expense of spectral resolution for GEO
- Consider MTG-IRS to be a good baseline instrument

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Changing landscape of scientific application (1)

- The future is all-sky
  - Provision of heterogeneity information is important
    - A homogeneous cloud is much easier to forward-model
    - NWP Centres consistently request sub-pixel heterogeneity information is included in Hyperspectral IR BUFR products
      - See for example: IASI-NG Science Plan
      - See for example: ITSC DA/NWP Working Group Report 2021
- The same can be said for surface-affected radiances.
  - Better homogeneity leads to an easier forward modelling process
  - With the advent of NEWP, we are likely to see more coupling of land surface models with atmospheric and ocean models. Surface-affected observations will become easier to use and more important.

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Changing landscape of scientific application (2)

- Homogeneity requirements also lead to important considerations for footprint size
  - A smaller footprint leads to a greater likelihood of finding a homogeneous scene
  - Review of CrIS footprint size by ITSC NWP/DA WG in 2016 endorsed a proposal to reduce the size of footprints.
  - See Wang et al., 2016 for one aspect of the analysis carried out.

- Global model resolutions continue to get smaller
  - Small grid boxes are no longer the preserve of limited area models

- 2 km is very good, maybe too good, but 50 km is too poor, given the vertical resolution of the information in an observation.
  - The gap between 2km and 10km is quite large

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Consider data dissemination mechanisms

- Future applications are likely to use more of the spectrum
  - Integration of chemistry transport models and strongly-coupled chemistry systems
  - Channel selections will be less and less relevant

- DBNet data usage
  - A large barrier to picking up DB-Net data is the lack of consistency with the global products.
  - Consider delivering global products in a way that allows a consistent DBNet product.
  - Centres value DBNet as a back-up to the global data supply but also because the improved timeliness means the observations are valuable for short cut-off forecast runs.