

Preliminary Results of Simulation of SOCRATES period with Global System for Atmospheric Modeling

Marat Khairoutdinov¹ and Christopher S. Bretherton²

¹School of Marine and Atmospheric Sciences and Institute for Advance Computational Science, Stony Brook University, NY

²University of Washington and Vulcan Inc., Seattle, WA

Motivation

- (Global) CRMs with horizontal grid resolutions of 4 km or less were shown to realistically simulate patterns of boundary layer stratocumulus and cumulus in the cold sectors of mid-latitude clouds, which have been a source of major bias in GCM, without cumulus or PBL parameterizations (Tomita et al. 2005; Vergara-Temprado et al. 2018).

- Southern Ocean boundary-layer cloud regimes (e. g. mixed-phase and supercooled liquid cloud, decoupled stratocumulus and cold-sector cumulus) rely on an adequate representation of the small-scale circulations that maintain these regimes.

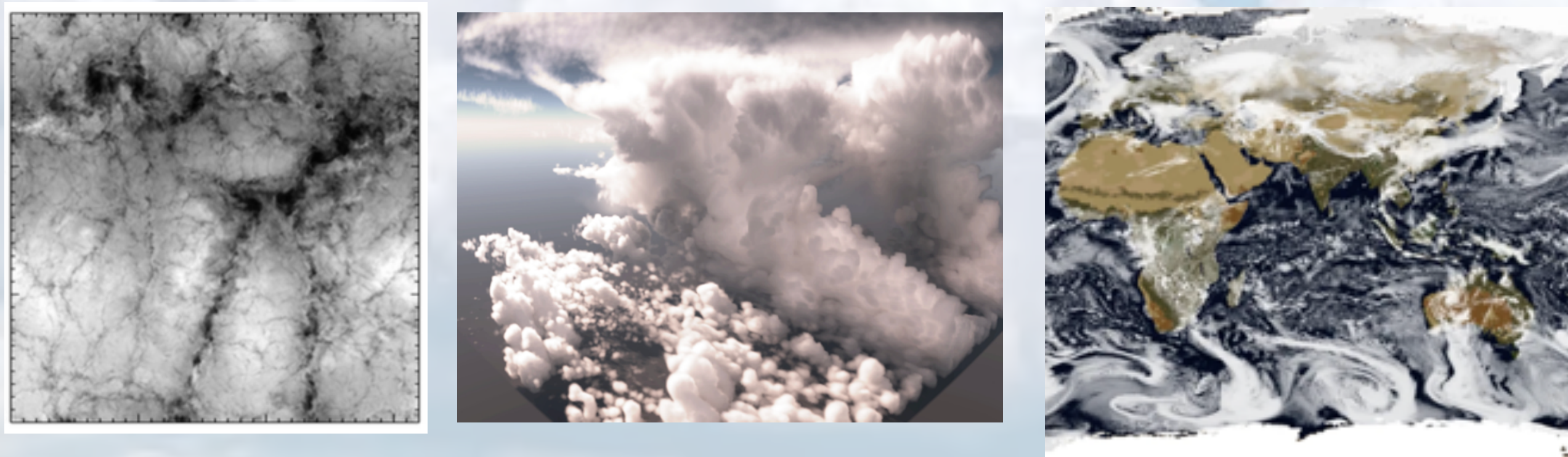
- While large-eddy simulation (LES) would be ideal approach, it is impossible to apply over large areas. Arguably, a Global CRM grid is much closer to this ideal than a GCM (with no actual clouds), so we hypothesize that it should better simulate the observed cloud processes over Southern Ocean.

- To facilitate better comparison with observations of different regimes, we use weather-nudged mode to reproduce basic large-scale flow patterns that existed during the Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study (SOCRATES) campaign held in Jan-Feb 2018.

SAM: System for Atmospheric Modeling

Cloud-Resolving Model (CRM) / Large-Eddy Simulation (LES) Model

- Cartesian or latitude/longitude grid
- Anelastic (no sound waves), non-hydrostatic; 2D or 3D;
- Smagorinski 1st order or 1.5 prognostic TKE SGS closure;
- Radiation packages: NCAR CAM3 and RRTM;
- 2nd-order space and 3rd-order Adams-Bashforth time differences for momentum;
- Conservation of momentum and kinetic energy;
- fully 3-D positive definite and monotonic transport (MPDATA) for all scalars;
- Several cloud microphysics packages of various complexity;
- Comprehensive land-surface model with different types of vegetation and interactive soil
- "Box-fill" method for the topography;
- Massively parallel (domain decomposition, MPI);

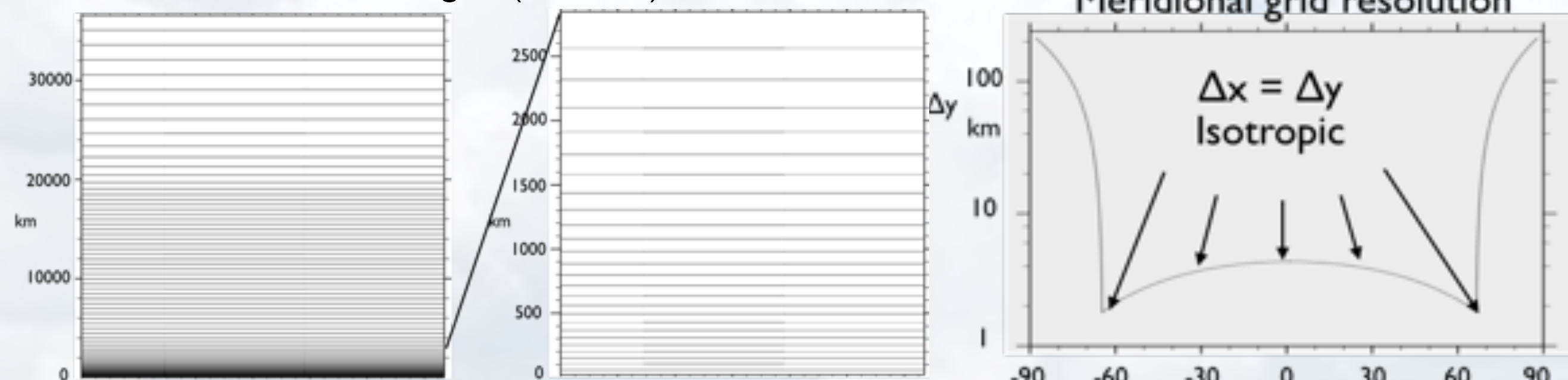


Global SAM Configuration

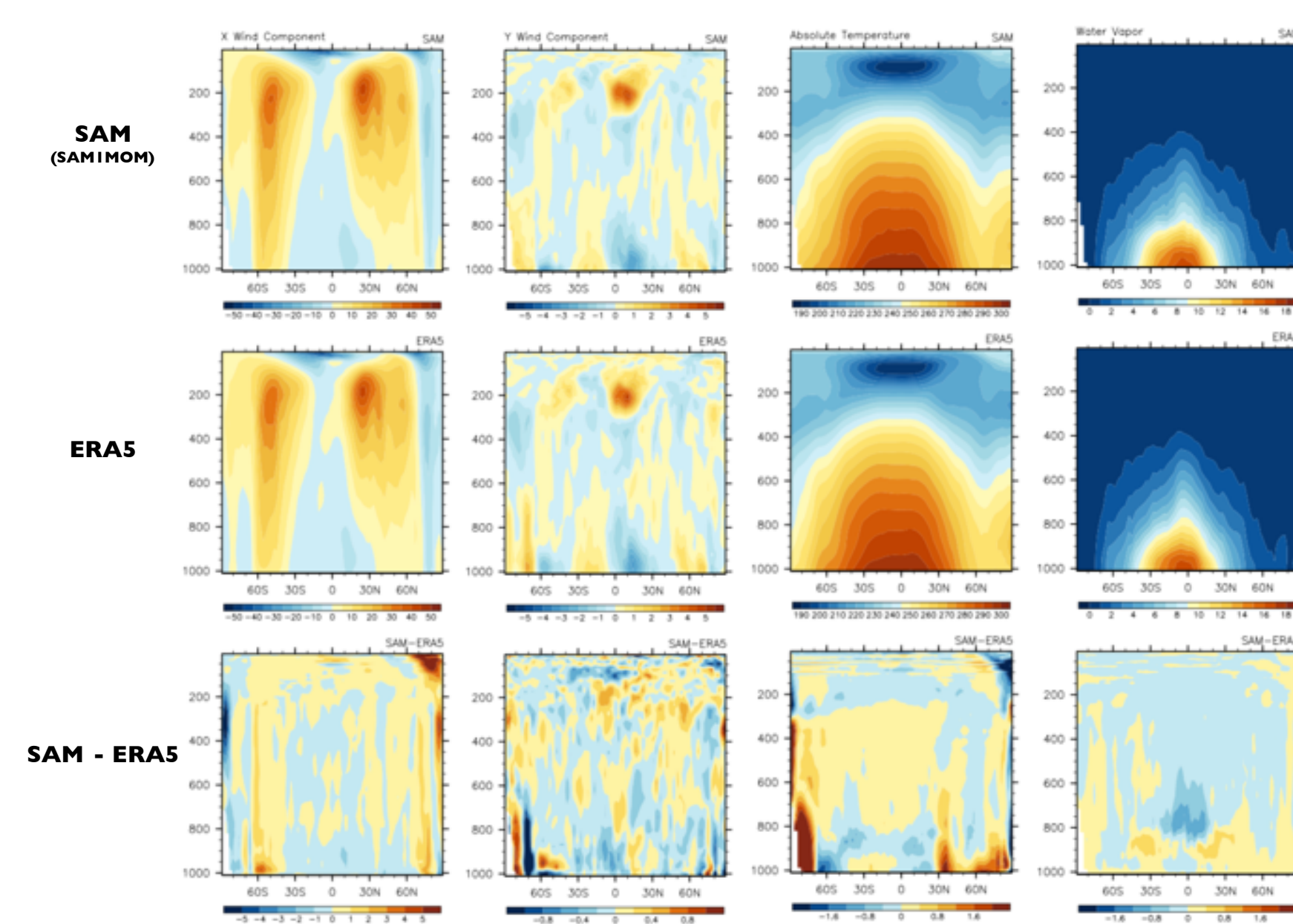
- Grid 4608 x 9216 x 74 (spacing 4 km at equator, 2-3 km over Southern Ocean)
- MPI parallelization using 4608 cores on NCAR's Cheyenne
- Period: February 16 - 21, 2018
- Initialization: ERA5
- Nudging of U, V, and T to hourly ERA5 over 24-hour timescale
- Microphysics: SAM1MOM, Morrison and Thompson
- Performance: 5 (SAM1MOM), 9 (Morrison), and 10 (Thompson) wall-clock hours per simulated day
- Output: hourly

Vertical grid (74 levels)

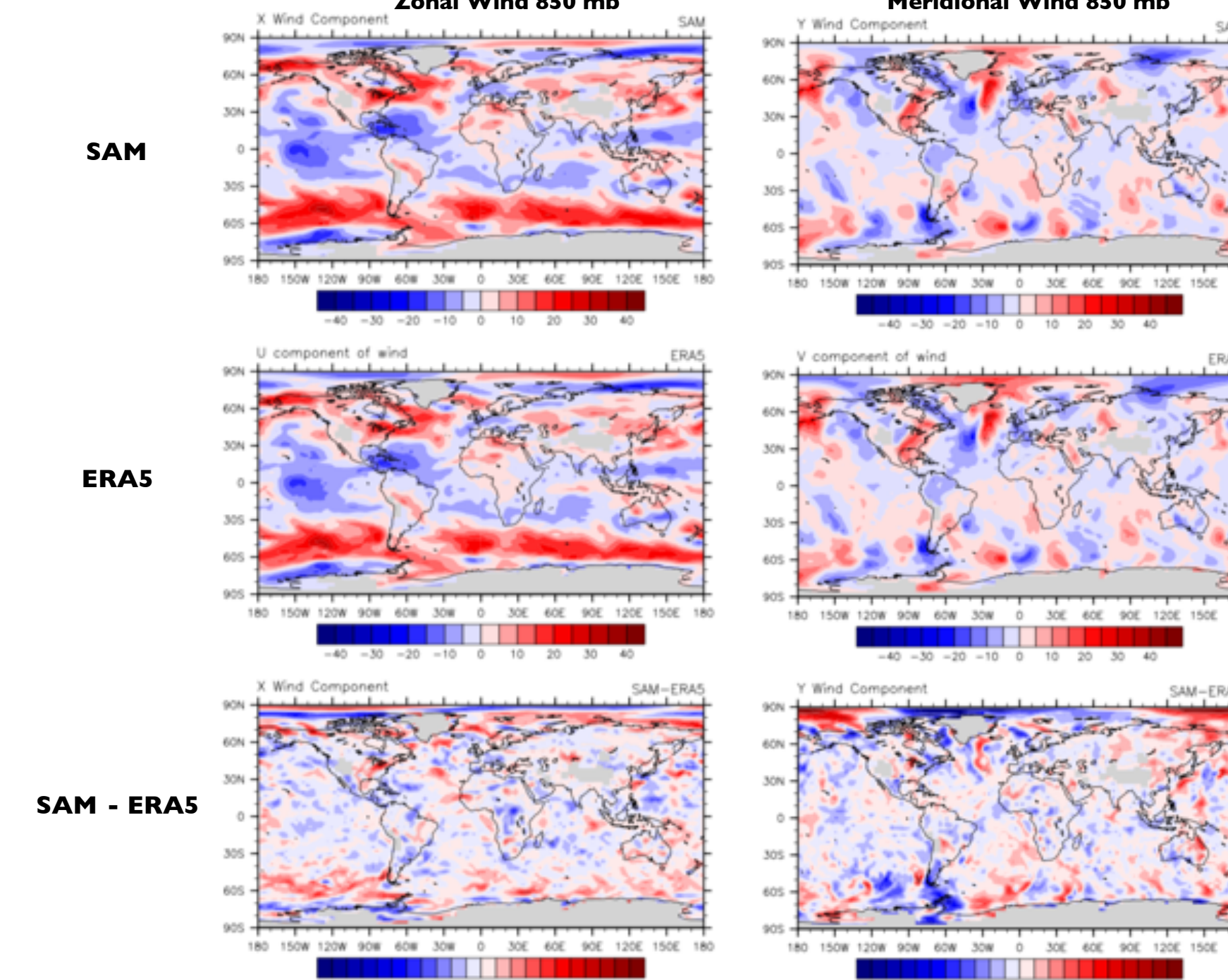
Meridional grid resolution



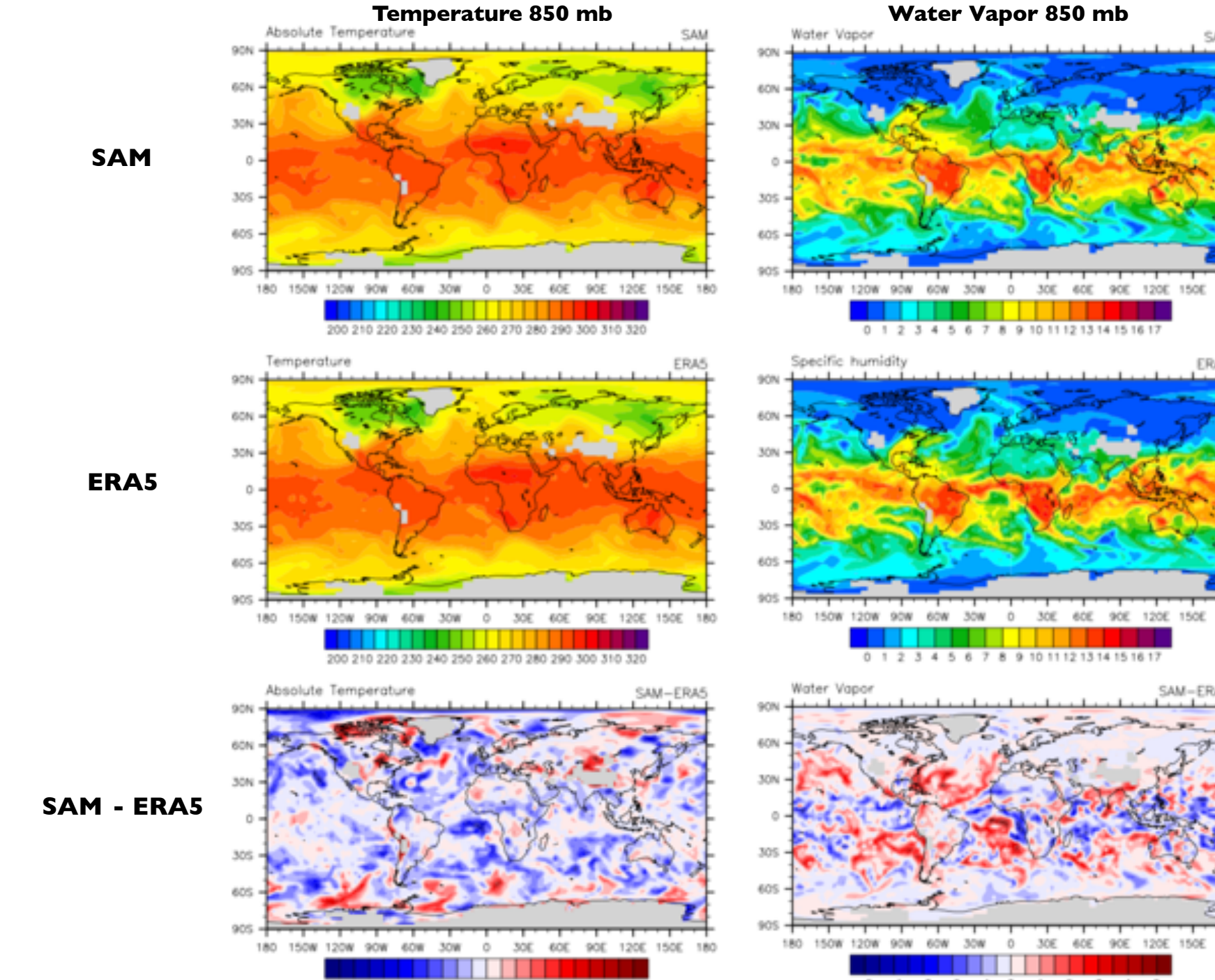
Zonal-mean fields averaged on day5 (Feb 21st)



Nudged Simulation: day5 (Feb 21st)

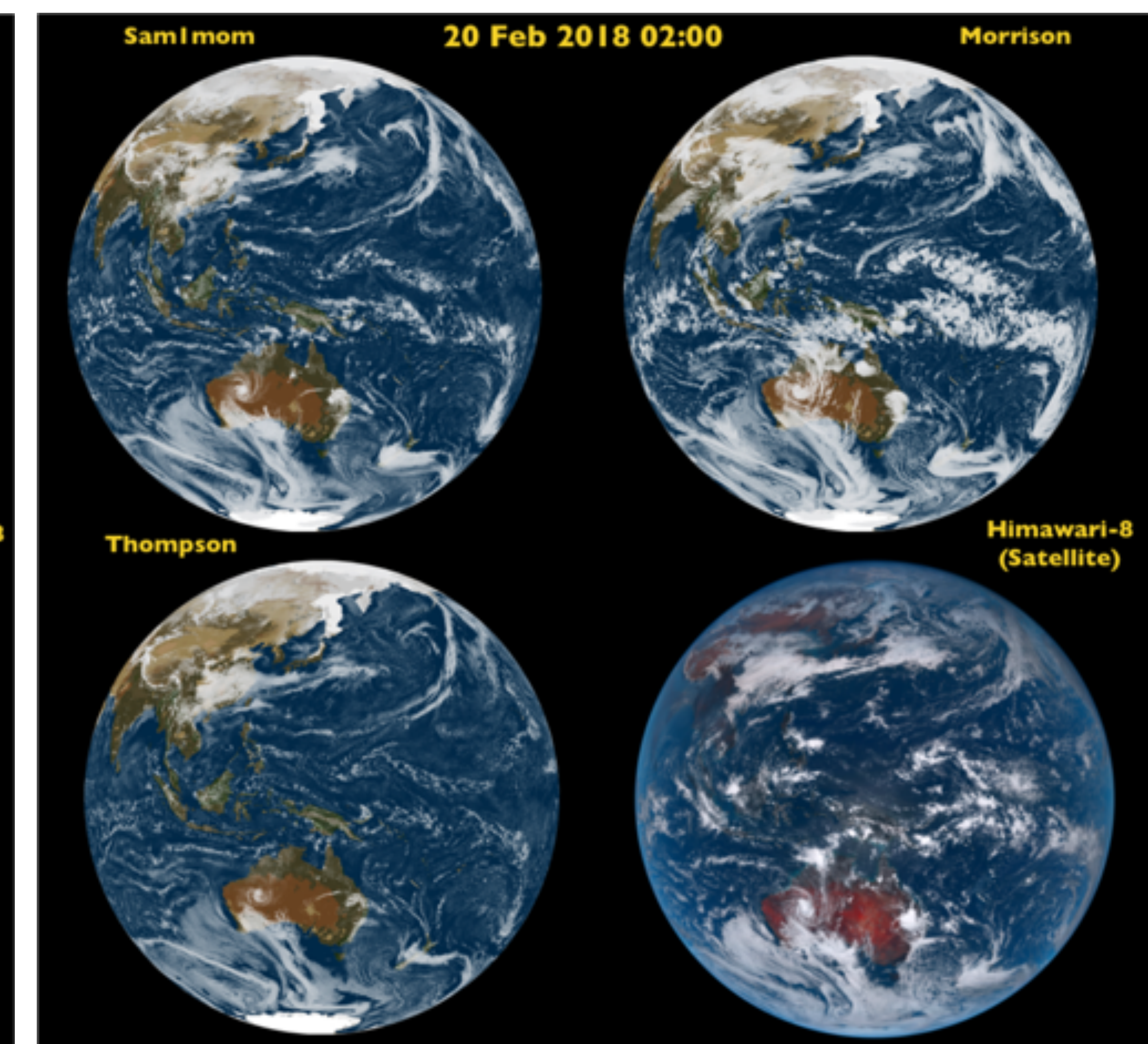
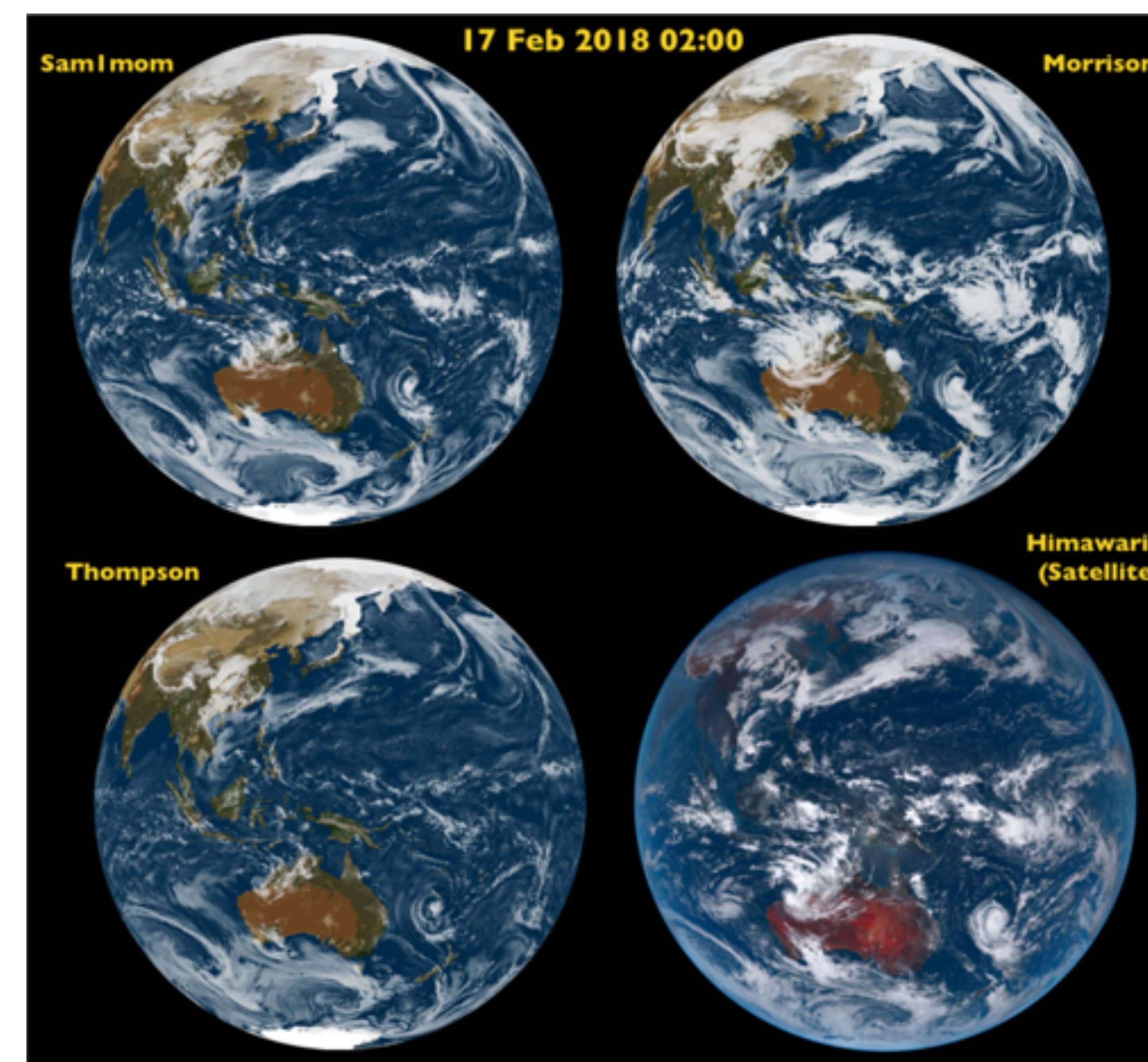


Nudged Simulation: day5 (Feb 21st)



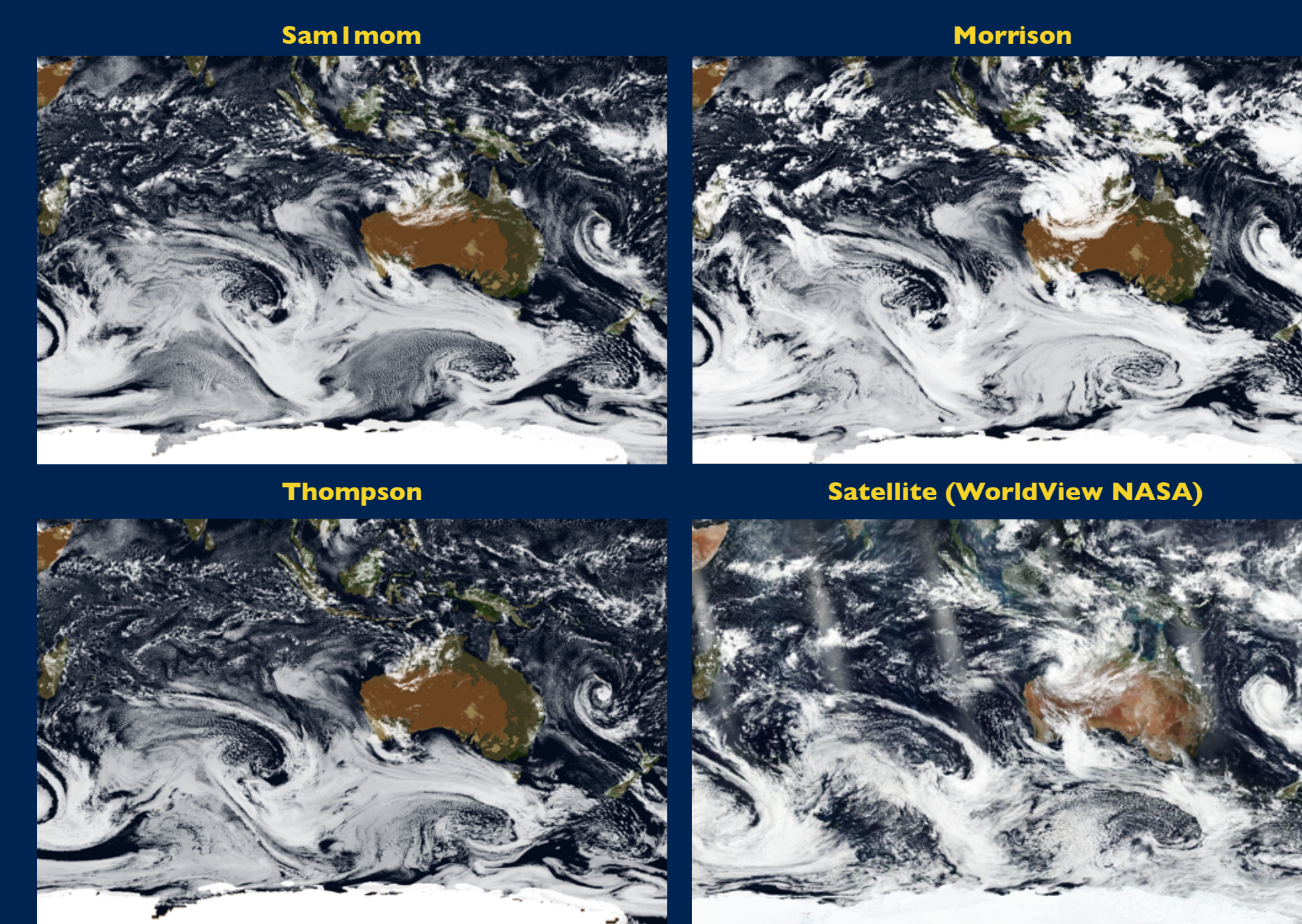
Outlook

- Overall, the preliminary results look quite encouraging for such a new model as global version of SAM;
- 24h-nudging to ERA5 appears to be pretty "gentle" and does not seem to affect the local PBL structure (from comparison of nudged and non-nudged runs), but allows to closely maintain the large-scale dynamic and thermodynamic patterns;
- The cloud patterns and vertical structure are strongly affected by the choice of cloud microphysics. All tested microphysics demonstrate pretty considerable biases in reproducing cloud cover over the world;
- Major effort will be made to better diagnose the model biases and to refine the microphysics using SOCRATES observations.



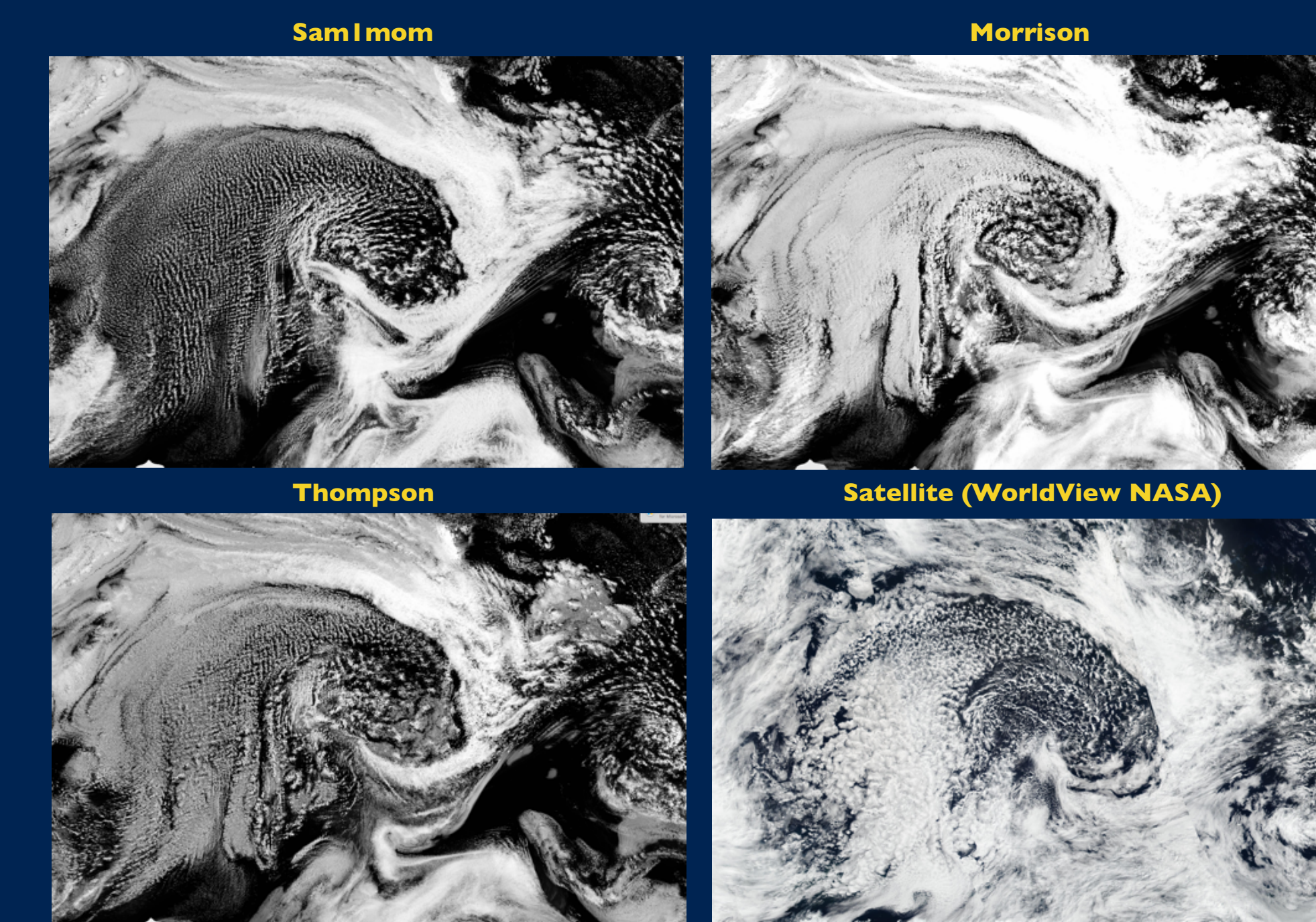
1st day (Feb 17th) of nudged simulations
resolution 2-3 km in mid-latitudes

Simulated vs Satellite Visible



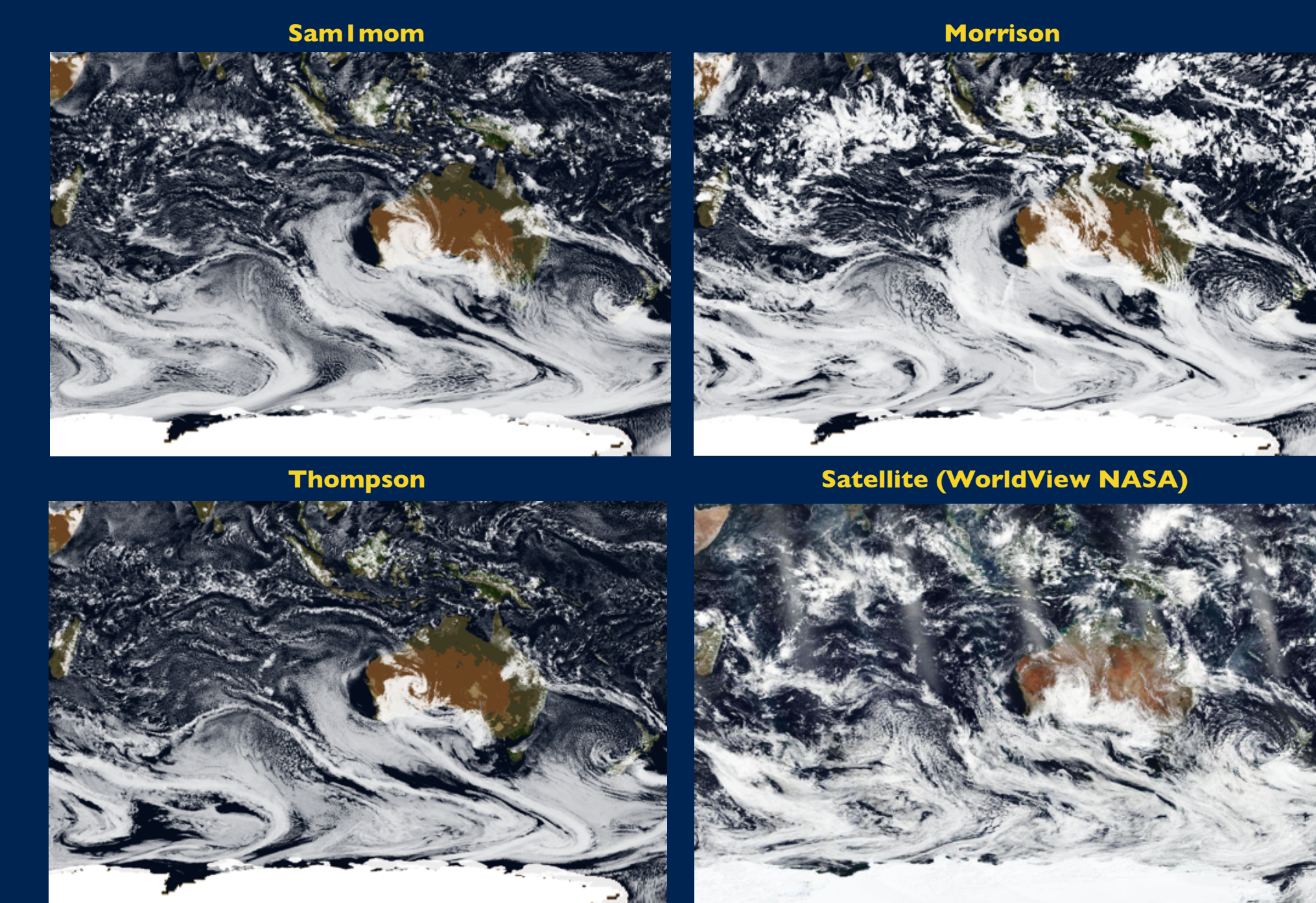
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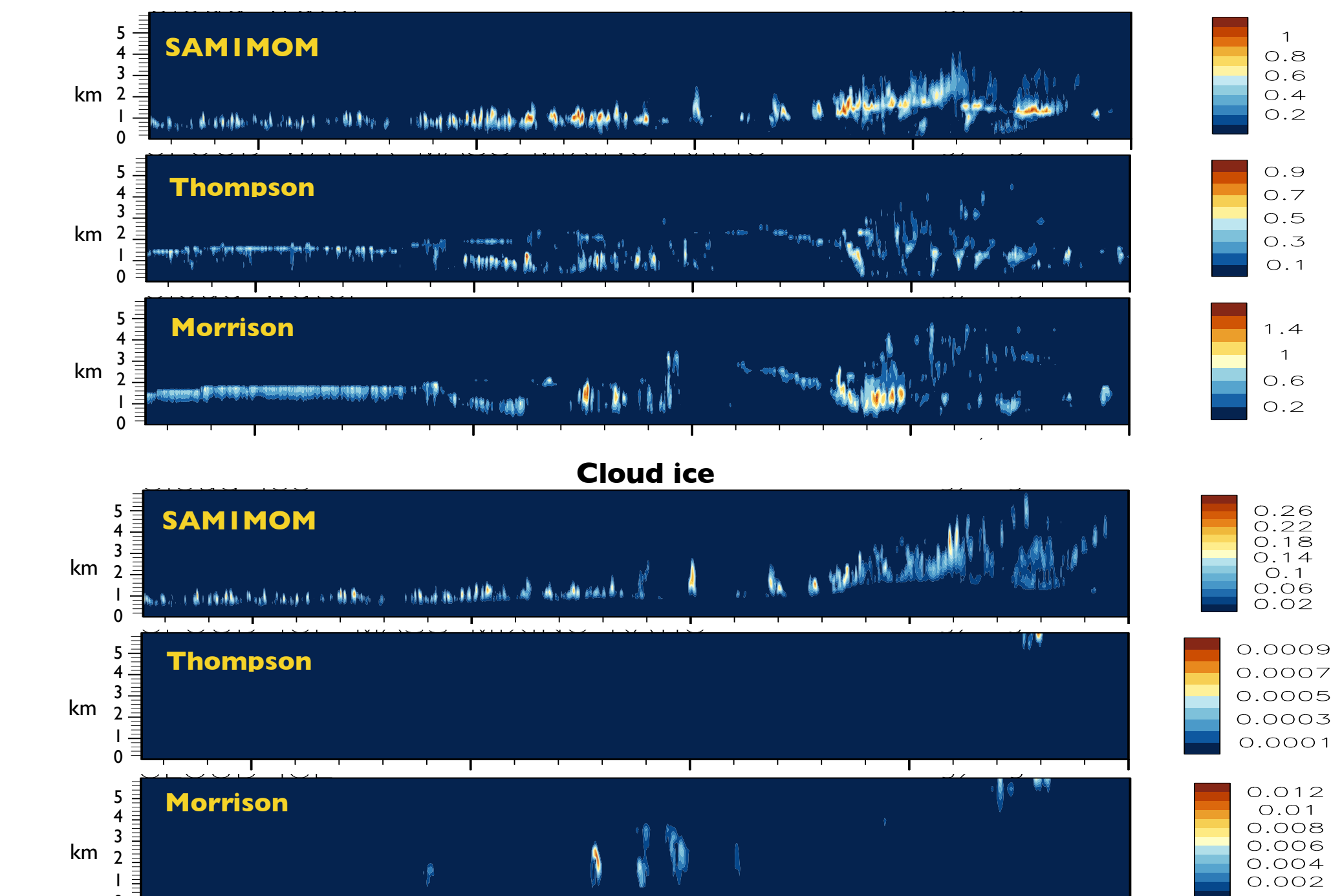


5th day (Feb 17th) of nudged simulations
resolution 2-3 km in mid-latitudes

Simulated vs Satellite Visible



Cloud water



West-east cross-section of simulated cloud fields through the middle of cold sector on the image on the left

Acknowledgements

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