LASSO-ENA Update

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Model prototyping: Heng Xiao [1] and Satoshi Endo[2]
Observations & analysis: John Rausch[2] and Damao Zhang[1]

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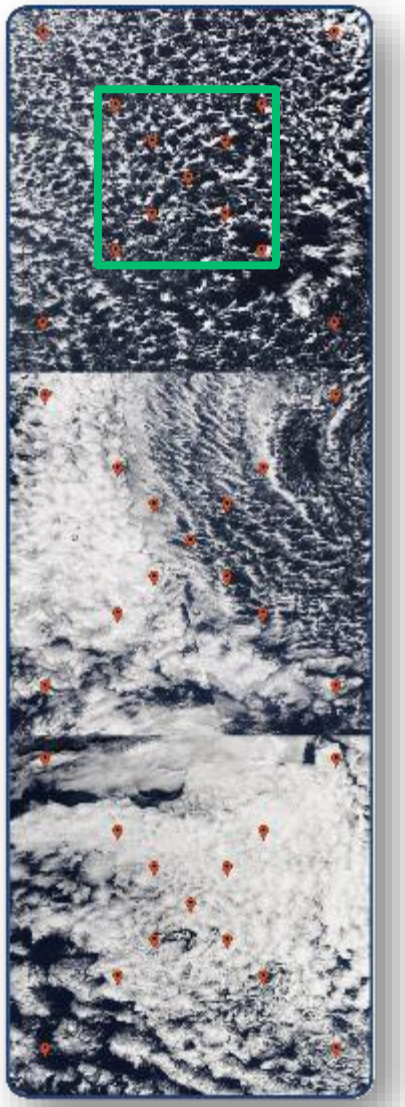
Where is the Eastern North Atlantic (ENA) observatory?

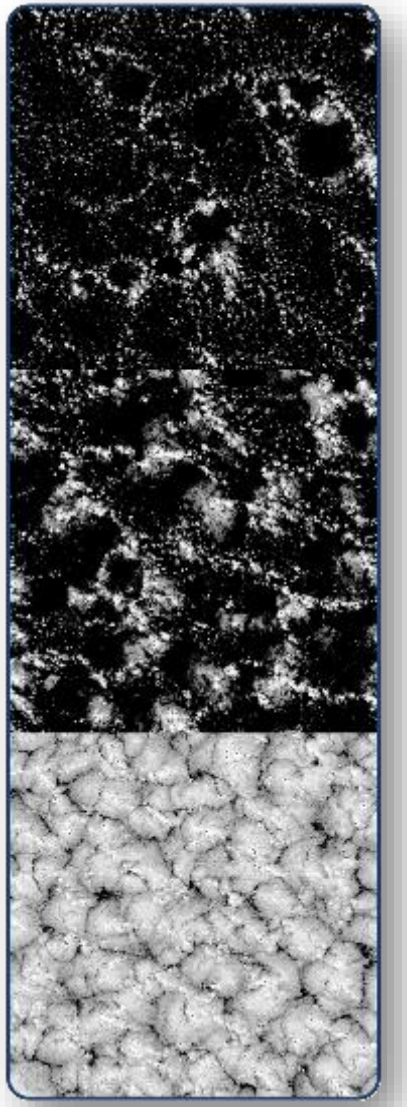
Primary LASSO-ENA science drivers



- Marine cloud organization in the middle latitudes
  - Open, closed, and transitioning regimes
- Precipitation processes
  - Specifically related to shallow marine clouds

MODIS observed clouds for example cloud regimes. Centered on ENA.

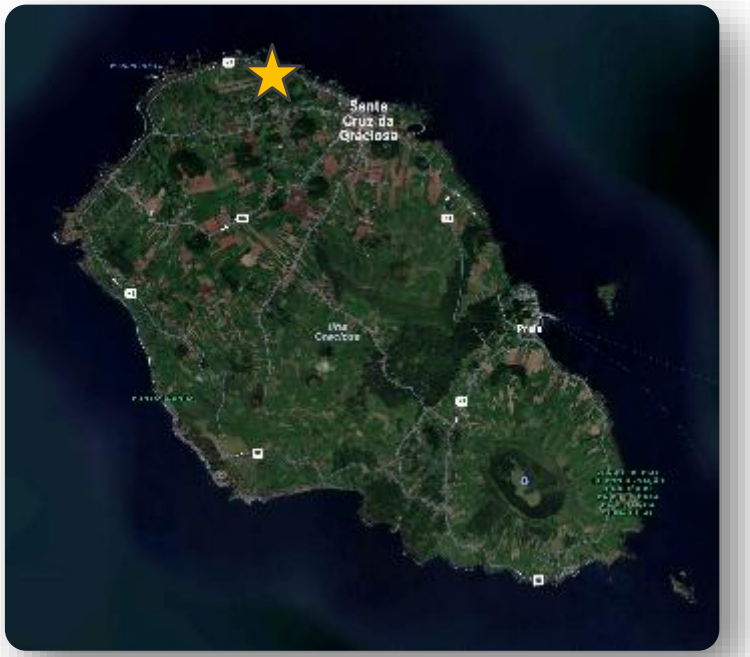
Simulated cloud regimes using SAM model and 250-km-wide periodic domain.



https://www.arm.gov/capabilities/modeling/lasso

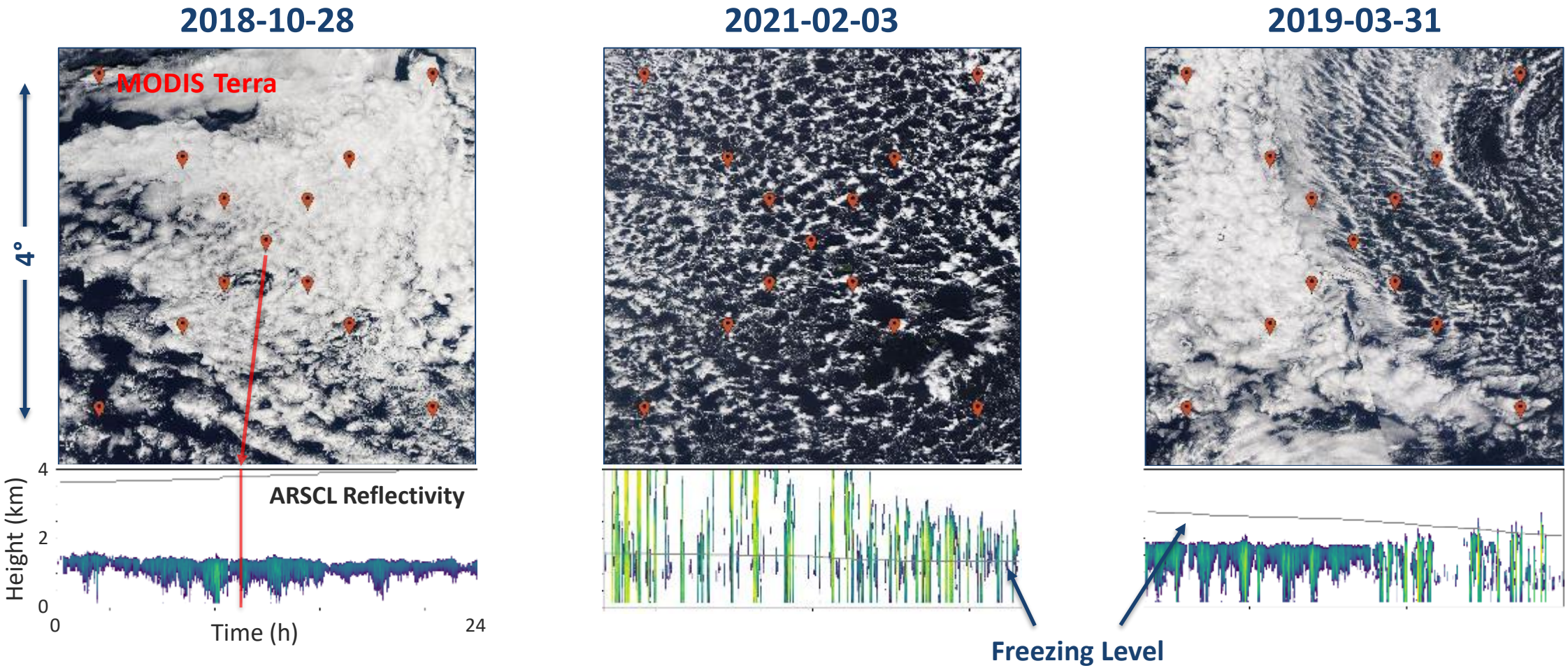
Case selection

- Looked for days with minimal island influence—want the cases to represent oceanic conditions for large-scale models
  - Initially focused on ACE-ENA campaign period, but it had too few "clean fetch" days
- Combined input from many sources
  - Jingjing Tian (PNNL) applied a machine-learning analysis to identify mesoscale cellular convection (Tian et al., JGR, in review)
  - Scanned satellite and ARSCL images for characteristic cloud patterns on days with favorable wind directions
  - Considered suggestions from constituents—still open to additional days if you have favorites



Roughly split between closed, open, transitioning cases

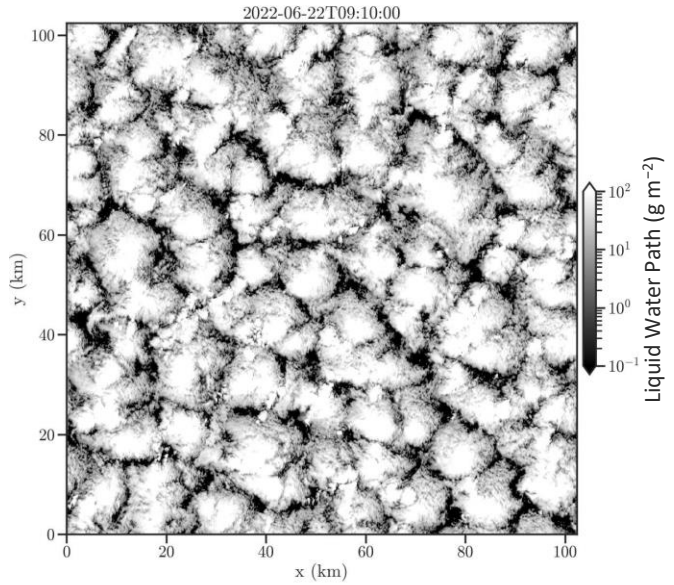
- Narrowed down to 63 cases for testing; will likely subset for final production



ENA modeling approach

- Using two modeling methodologies…
- Periodic domains with SAM
  - Forced with profiles from ERA5, MERRA-2, and possibly others
  - Cheap domain for ensemble testing: 25-km wide and Δx=100 m
  - Large-domain for better organization: ~100-km domain and Δx=100 m
  - Microphysics
    - Initial runs with bulk-Morrison and specified cloud-droplet concentrations
    - Finding better behavior with spectral-bin microphysics
- Nested domains with WRF
  - Initial testing used PINACLES anelastic model for speed—decided to use WRF for production runs
  - WRF needed for intermediate mesoscale grid spacings and more complex cloud parameterization options

SAM, 22-Jun-2022
100-km Domain, Δx=100 m



What simulations are available today?

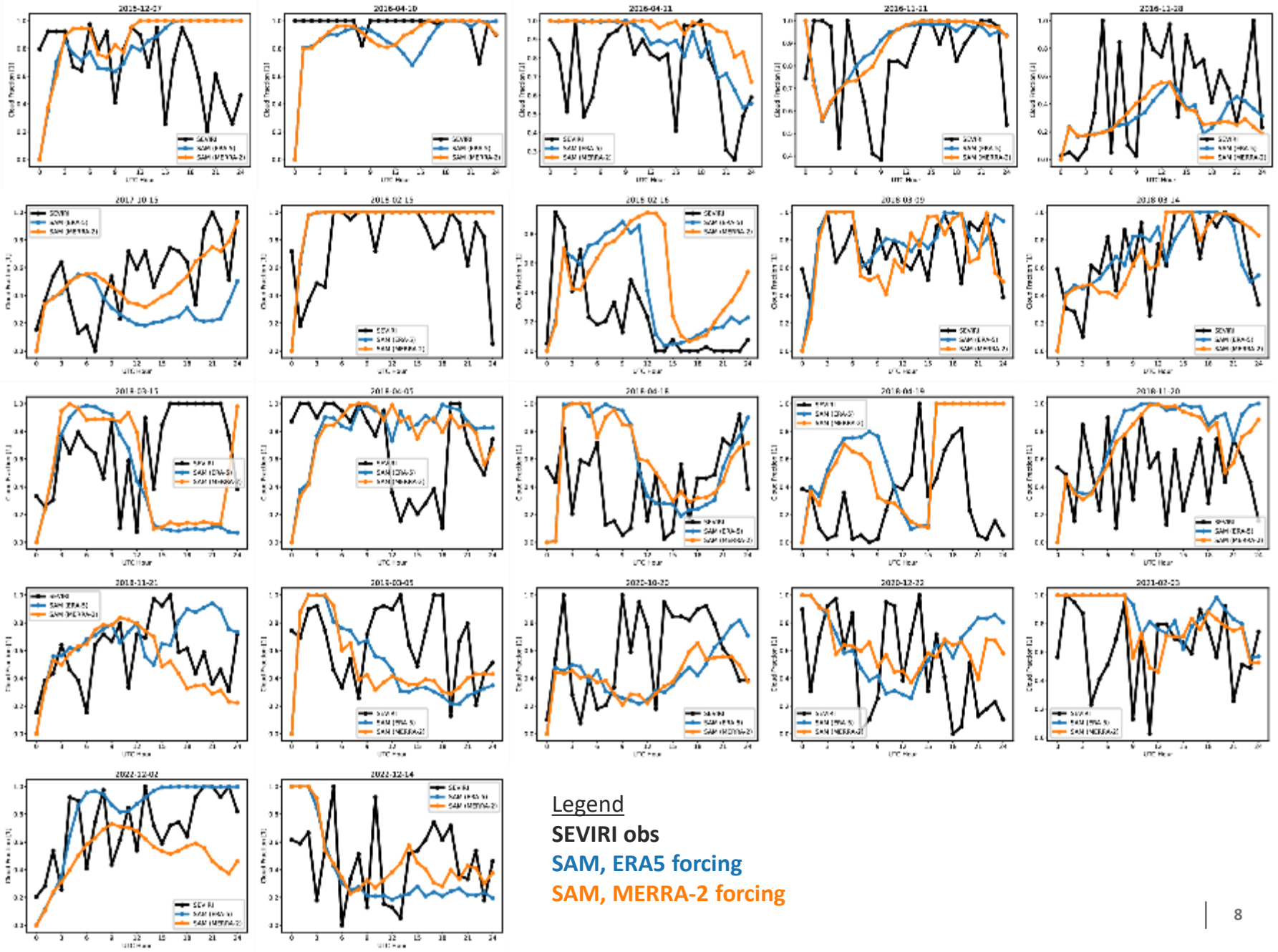
- Periodic SAM runs with bulk microphysics
  - Morrison microphysics, specified droplet number
  - 63 case dates roughly split between closed, open and transitional cases
  - 2-member ensembles using ERA5 or MERRA-2 forcing
  - 25-km-wide domain
- Periodic SAM runs with spectral-bin microphysics (SBM)
  - Hebrew Univ. spectral-bin model, specified total (aerosol+cloud) particle number (w/ & w/o ice)
  - Selected cases to evaluate impact of SBM, initially focused heavily on closed-cell cases
  - Mix of 25 and 102-km-wide domains
- Nested WRF runs with Morrison microphysics
  - Handful of test cases—not our highest priority at this point

Small-domain prototyping with SAM:

Open-cell cases

- **ERA5** and **MERRA-2** behave similarly
- Cloud fraction is reasonable for most non-overcast cases (to right)

Cloud Fraction Time Series at ENA: Sims vs. SEVIRI



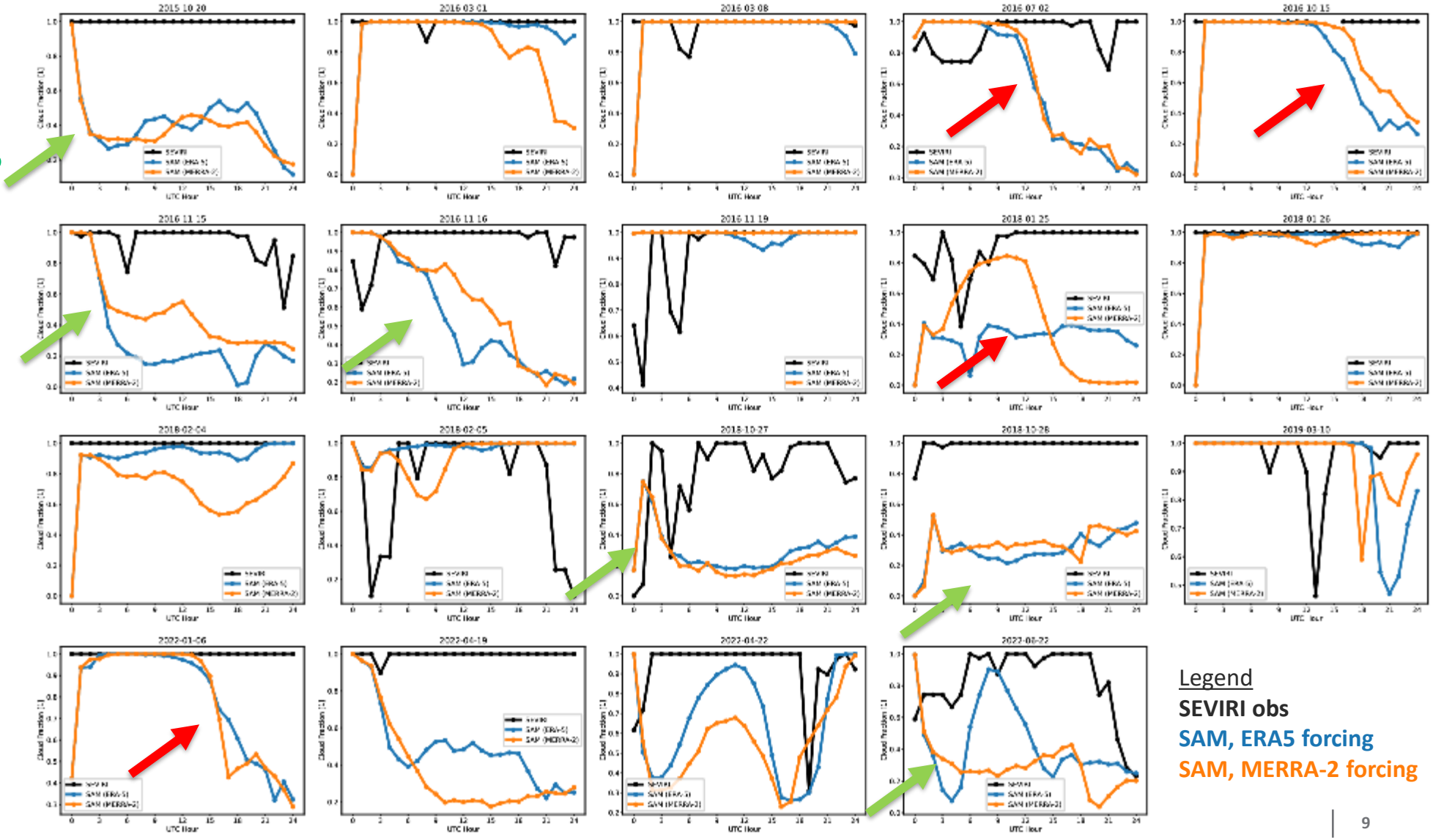
Legend
SEVIRI obs
SAM, ERA5 forcing
SAM, MERRA-2 forcing

Small-domain prototyping with SAM:

Closed-cell cases

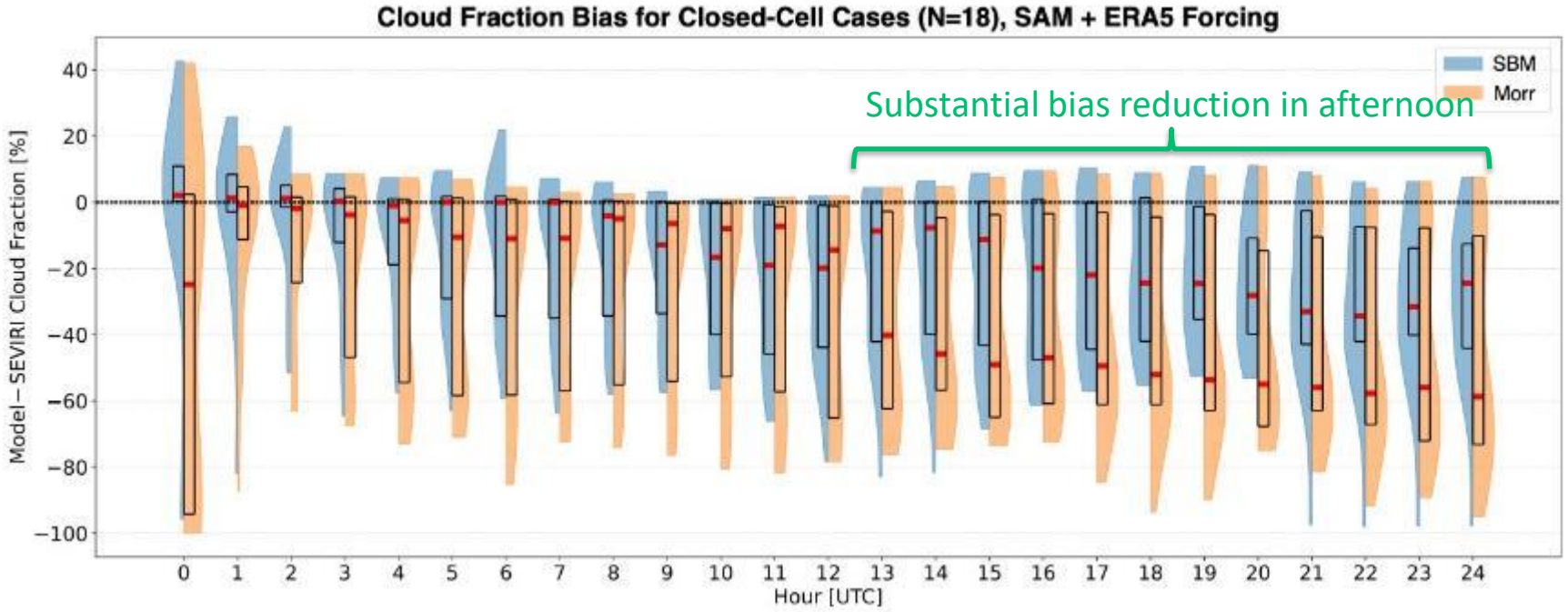
- Overcast cases do not maintain cloud deck with bulk Morrison microphysics

Cloud Fraction Time Series at ENA: Sims vs. SEVIRI



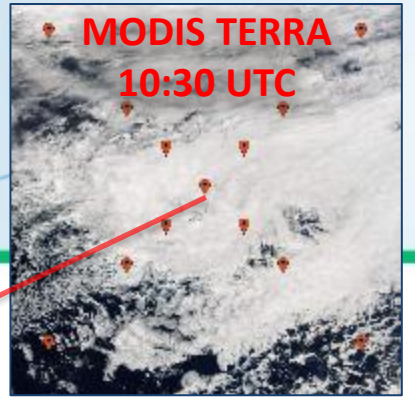
The one sensitivity test showing promise for overcast conditions…

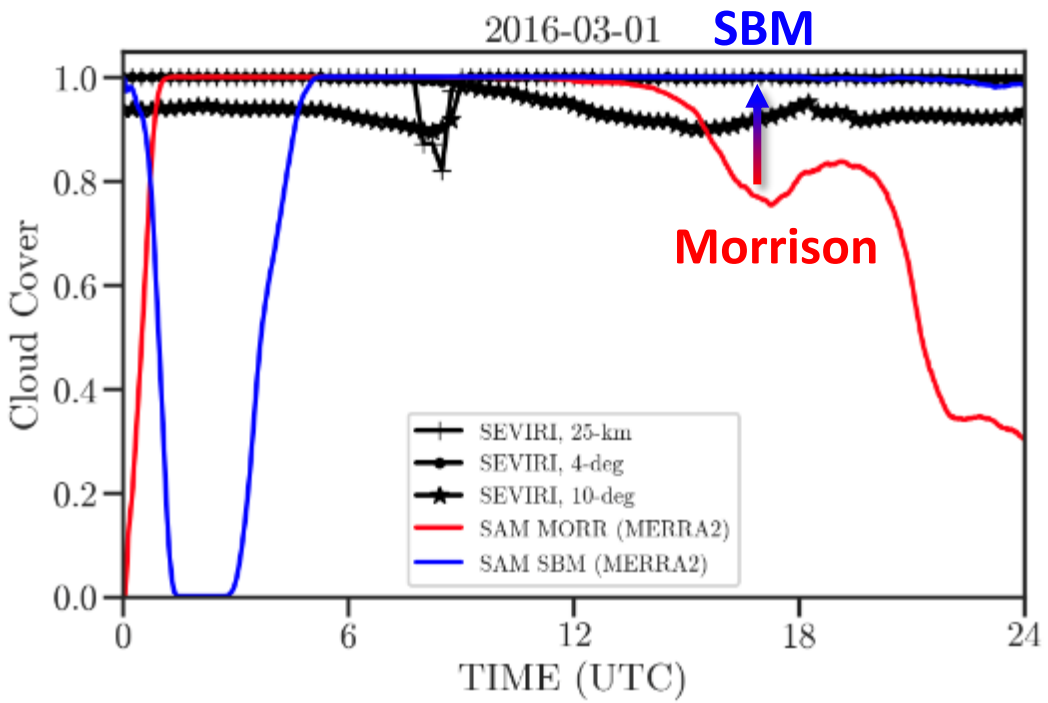
- What does not seem to make an improvement
  - Grid resolution
  - Grid aspect ratio
  - Domain size
  - Ice vs. no-ice (closed cells typically too short to have ice—ice helps open cells)
- Spectral-bin microphysics shows promise
  - Originally used Morrison with fixed droplet number of 50 per cc
  - Default spectral-bin still rained out and did not maintain afternoon clouds—aerosols were depleted
  - **Spectral-bin with fixed total particle number is "the winner" right now**



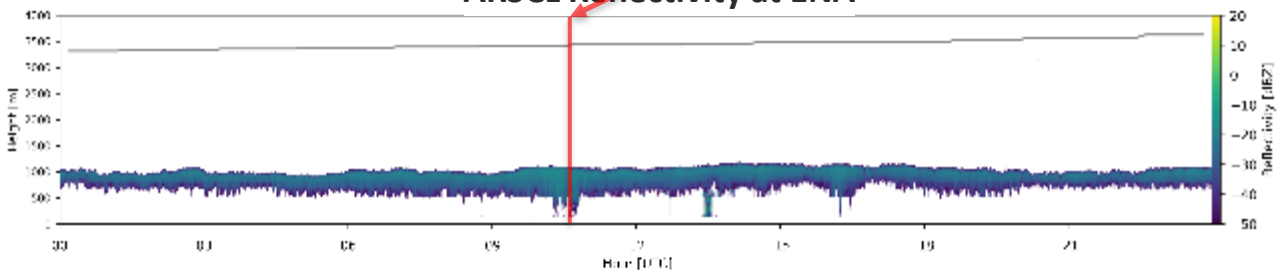
Impact of Spectral-Bin MP instead of Morrison

- Cloud fraction increases when using spectral-bin MP

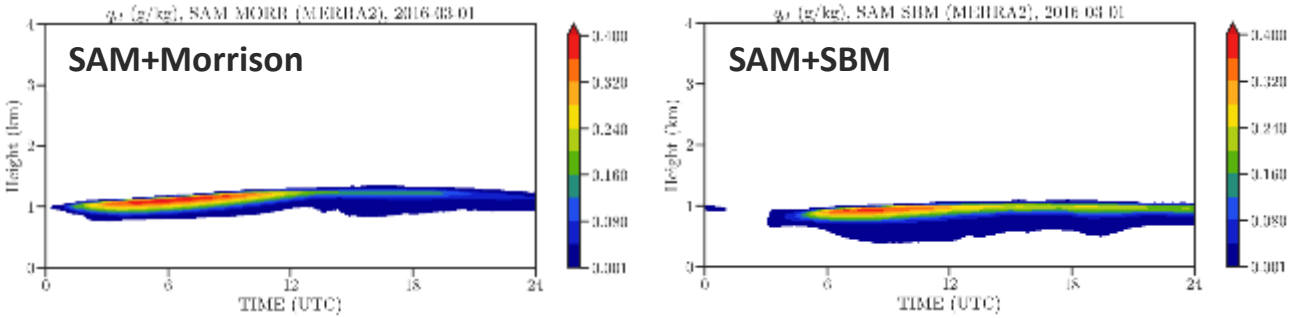




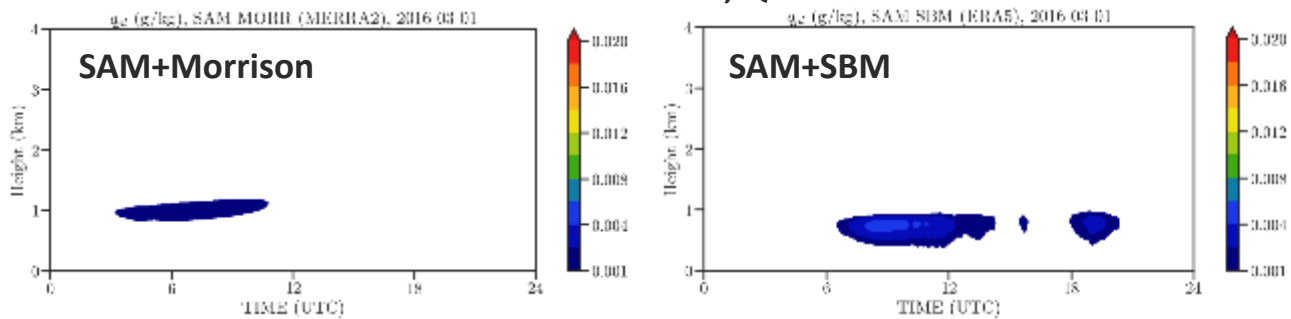
ARSCL Reflectivity at ENA



Cloud Water, Qc



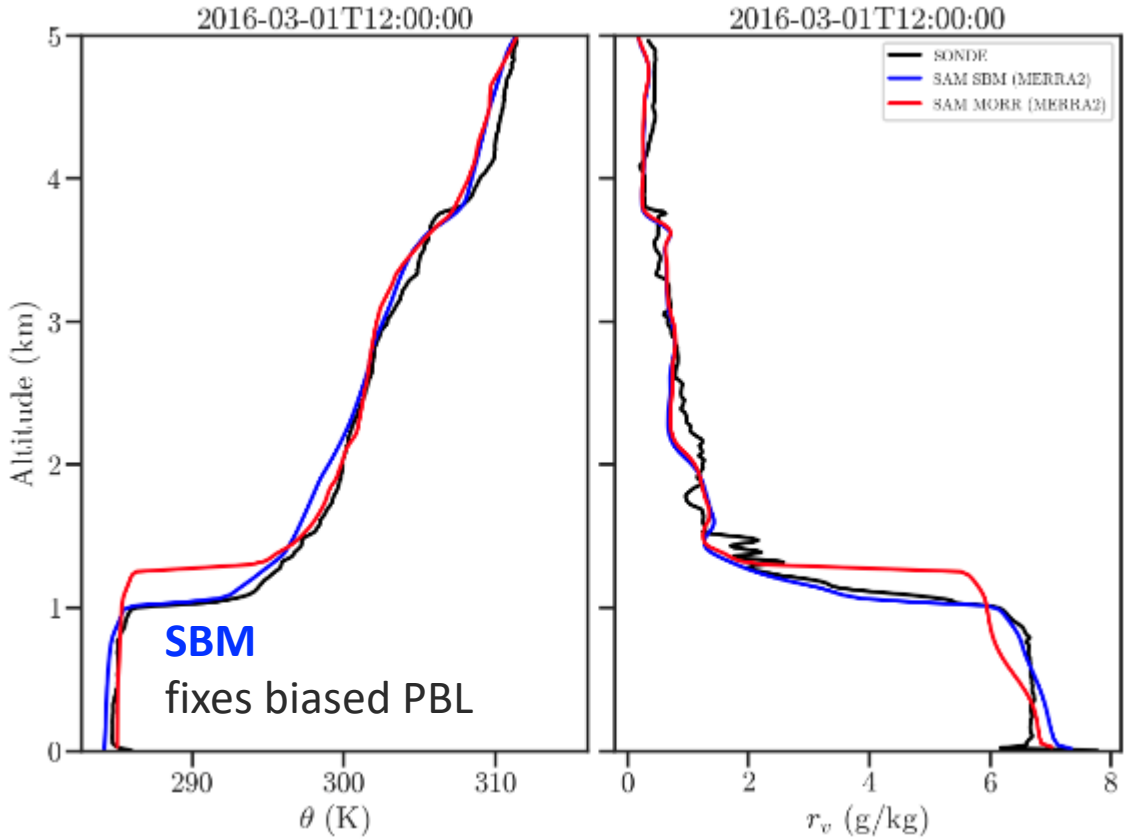
Rainwater, Qr



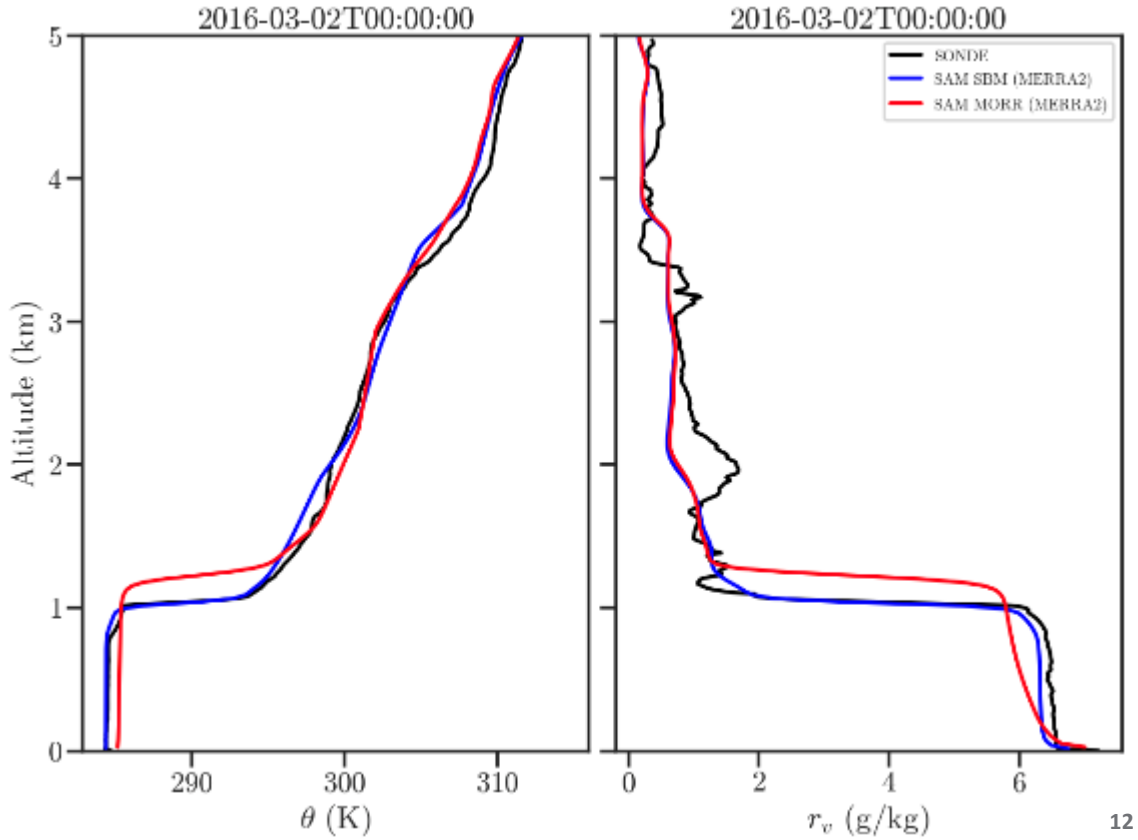
Spectral-Bin MP impact on thermodynamic profile

- Increased clouds due to SBM alter coupling to surface and often improve the profiles

1-Mar-2016 12 UTC (12 h into run)

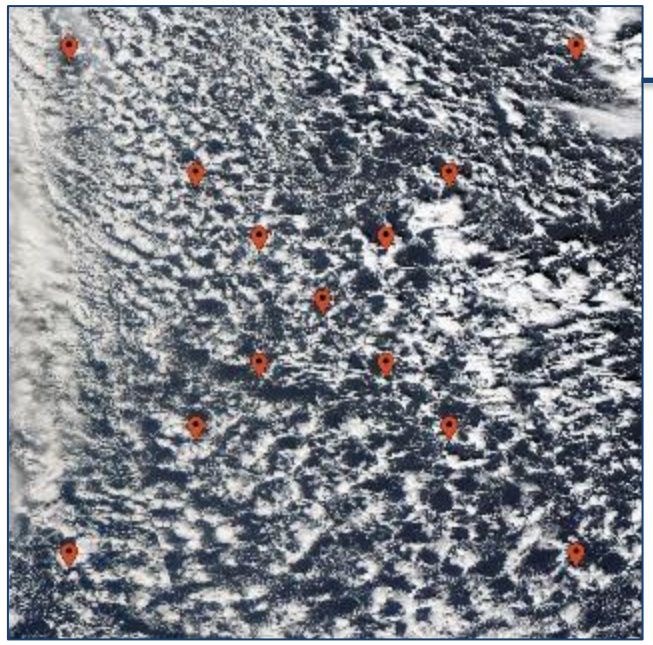


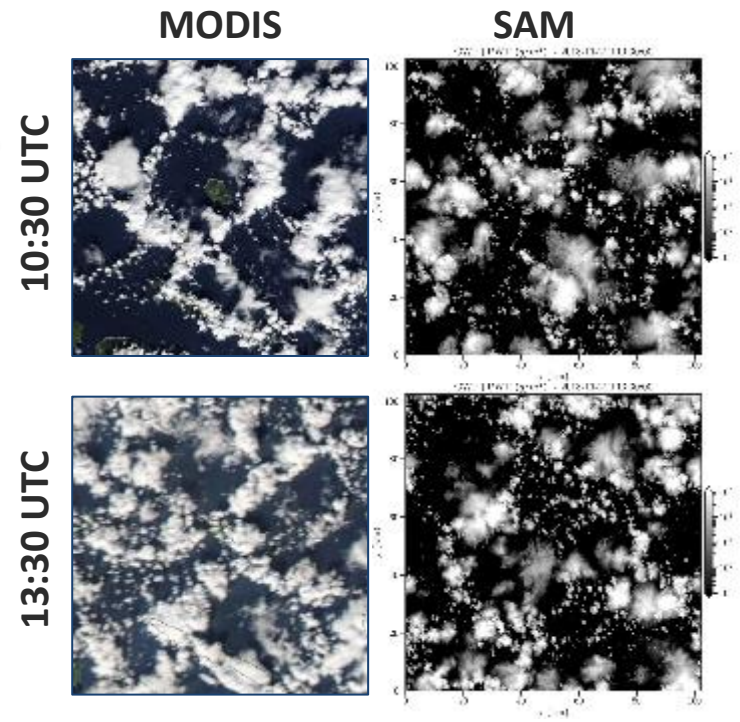
2-Mar-2016 0 UTC (24 h into run)

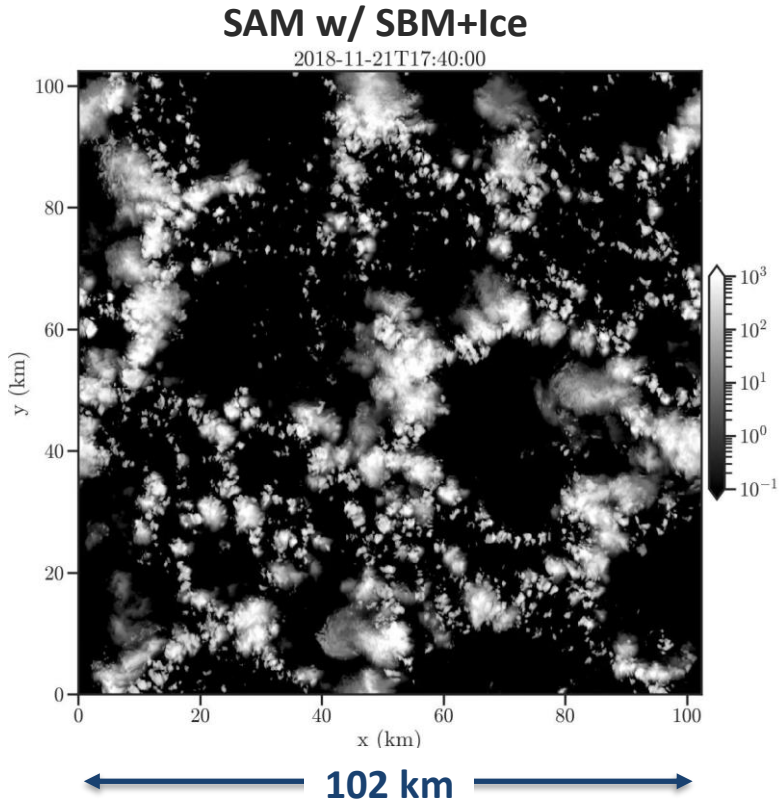


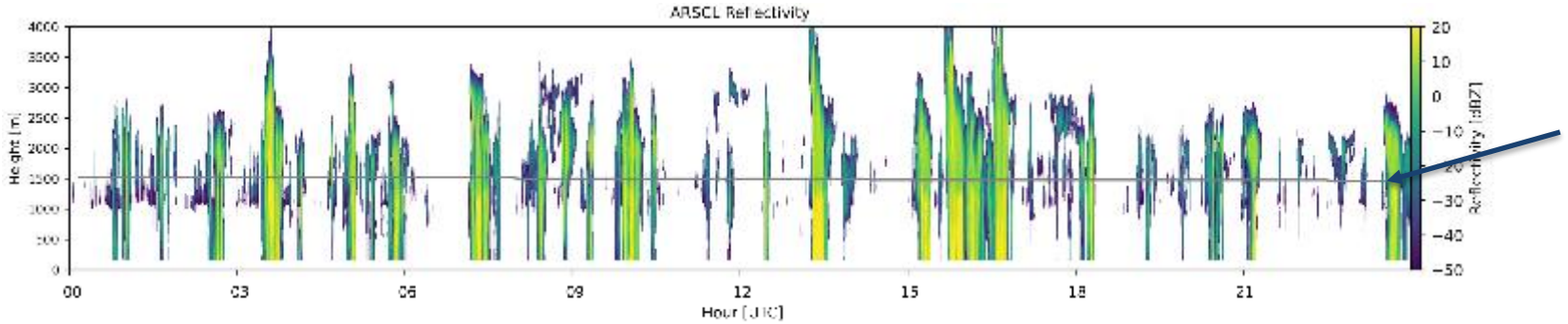
Open-cell cases complicated by ice phase

- Difficult to find warm-phase open-cell days with clean fetch; we have few summer days
- SBM + Ice = Computationally expensive; 21 days to get this run





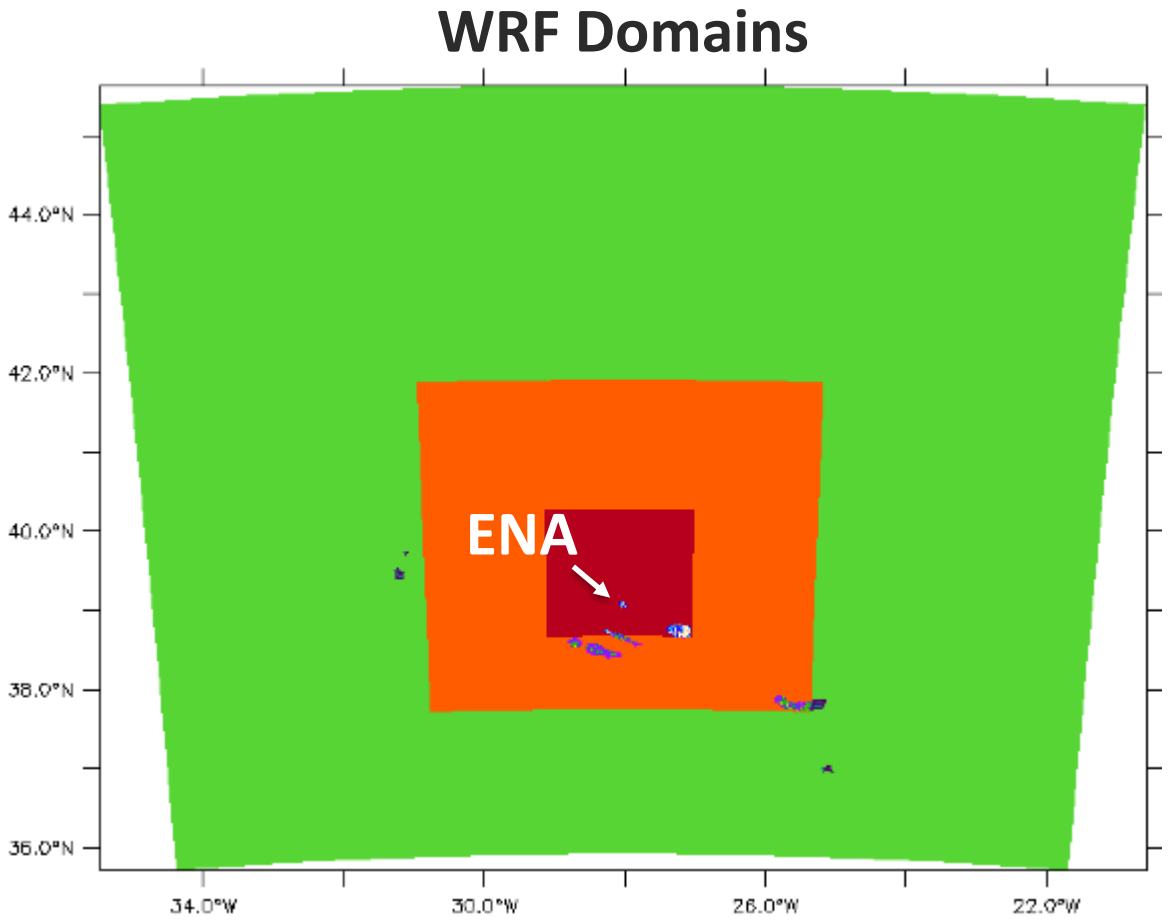




WRF with 3 nested domains

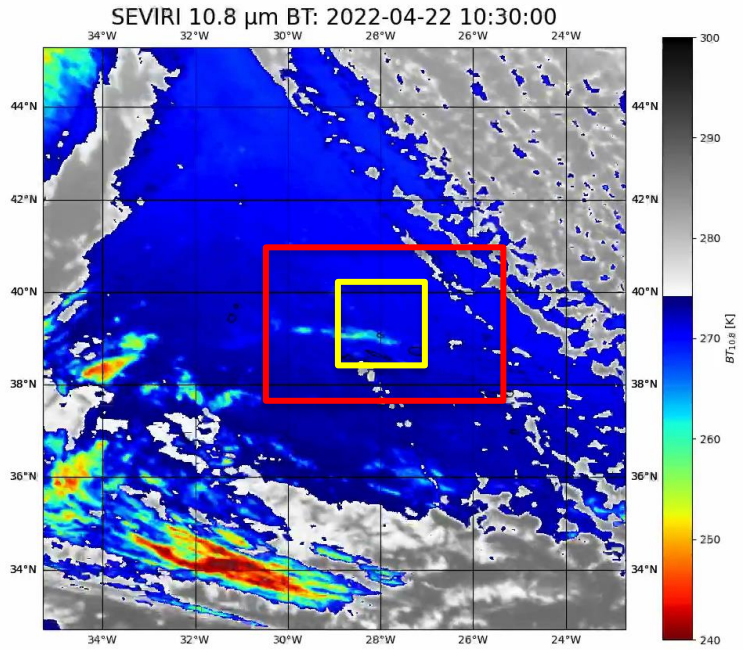
Model configuration

- 3 domains
  - Δx=2500, 500, & 100 m
  - Width=1125, 465, & 175 km
- ENA offset to the south to permit turbulence spin-up
- Include island topography
- Using Morrison microphysics due to cost

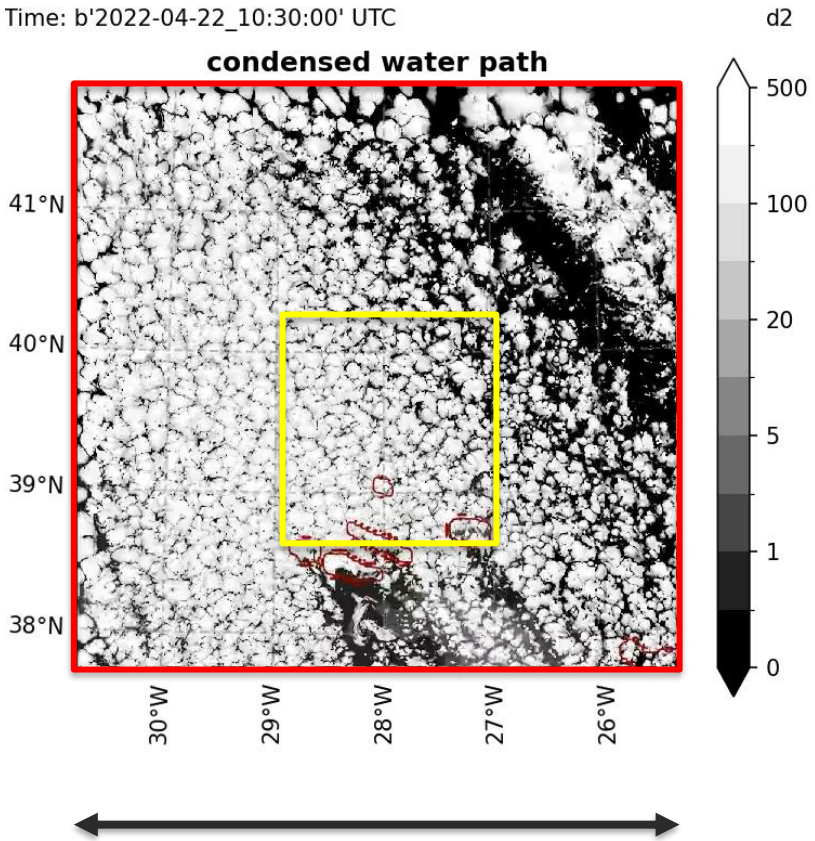


Capturing aspects of synoptic patterns and islands

SEVIRI Satellite

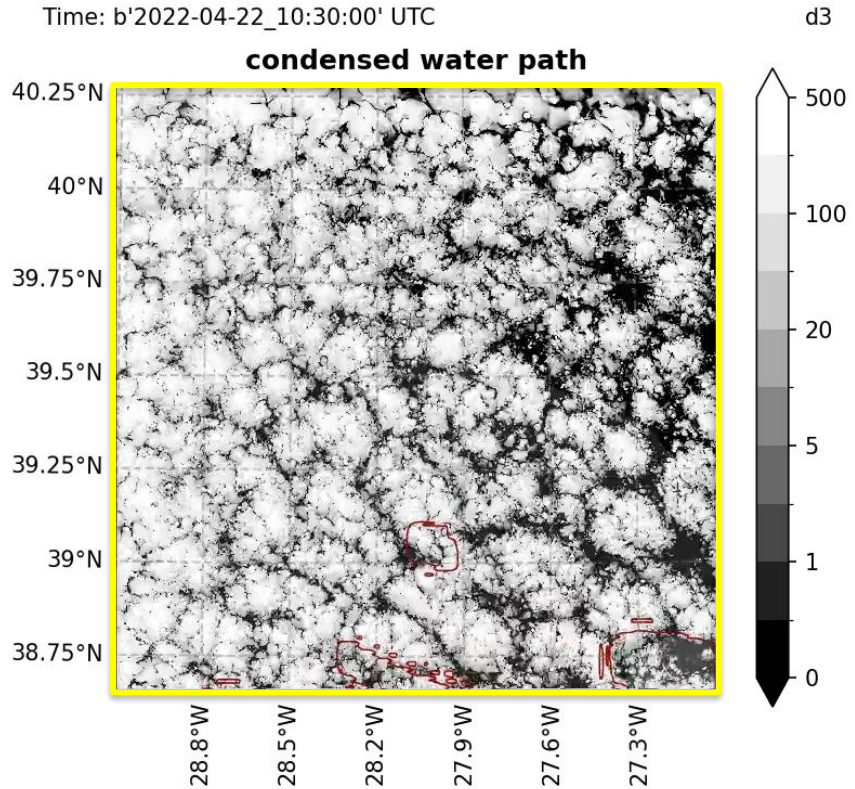


WRF – Domain 2



475 km, Δx=500 m

WRF – Domain 3



175 km, Δx=100 m

Data formats…

- LASSO-ShCu provides raw WRF files; LASSO-CACTI provides raw WRF plus subsets
  - Subset files group variables by category and add some post-processed fields like CAPE and de-staggered winds
- WRF runs can easily mimic the CACTI approach by using the same post-processing code
- Is it worth post-processing SAM output for users?
  - Default output is “binary-by-rank,” which we will convert to netCDF
  - SAM separates data into separate files for 2-D, 3-D, and statistics (mostly domain-average profiles)

File sizes for SAM

Small Domain

	25-km Domain Bin MP, no ice			25-km Domain Bin MP w/ summary ice output			25-km Domain Bin MP w/ all ice output		
	OUT_STAT	OUT_2D	OUT_3D	OUT_STAT	OUT_2D	OUT_3D	OUT_STAT	OUT_2D	OUT_3D
Output freq. (minutes)	2	5	15	2	5	15	2	5	15
Size per run (MB)	164	1,873	565,248	164	1,873	847,872	164	539,424	1,978,368

Large Domain

	102-km Domain Bin MP, no ice			102-km Domain Bin MP w/ summary ice output			102-km Domain Bin MP w/ all ice output		
	OUT_STAT	OUT_2D	OUT_3D	OUT_STAT	OUT_2D	OUT_3D	OUT_STAT	OUT_2D	OUT_3D
Output freq. (minutes)	2	5	15	2	5	15	2	5	15
Size per run (MB)	164	30,240	8,990,208	164	30,240	13,485,312	164	30,240	31,465,728
# of Possible Runs in 2 PB	~200			~150			~50		

Is 30-minute 3-D output acceptable to permit more cases?

LASSO-ENA plans…

- Generating simulations in 2025
- Periodic domains for 20–40 cases with SAM
  - Spread across cloud regimes (open, closed, transitional)
  - Basic aerosol sensitivity tests
  - Likely with spectral-bin microphysics if results hold across cases
- Nested domains for a handful of cases with WRF
  - Larger domains restrict the number of cases we can save

- We want to know what will be used… where do you see value?
  - Contact lasso@arm.gov if you would like access to the simulations before the formal release

Discussion topics for LASSO-ENA

- How do you envision using LASSO-ENA?
- Adequate case selection?
- Desires for model configuration changes?
- Importance of ice phase?
- Do we need the nested WRF runs?
- Output needs and expectations, e.g., variables and frequency?

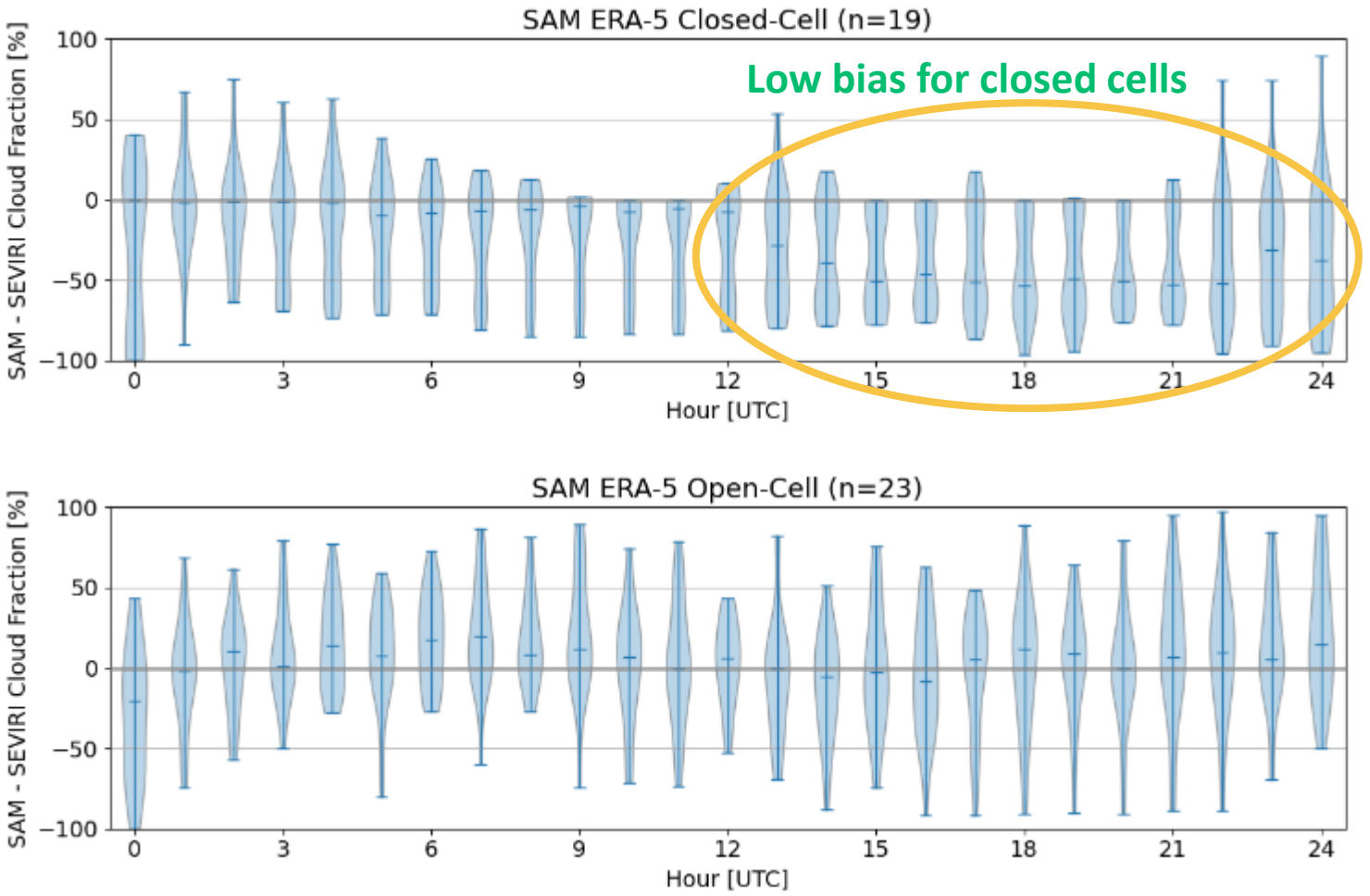
Getting more information for LASSO

- Website: https://www.arm.gov/capabilities/modeling/lasso
- Technical documents
  - LASSO-ShCu: https://www.arm.gov/publications/tech_reports/doe-sc-arm-tr-216.pdf
  - LASSO-CACTI: https://lasso-cacti-doc.arm.gov/latest/index.html
- Bundle browsers for data downloading
  - LASSO-ShCu: https://adc.arm.gov/lassobrowser
  - LASSO-CACTI: https://adc.arm.gov/lasso/#/cacti
- Questions and help
  - Discourse forum: https://discourse.arm.gov/c/lasso/
  - Support email: lasso@arm.gov

Summarizing cloud fraction for ENA simulation tests

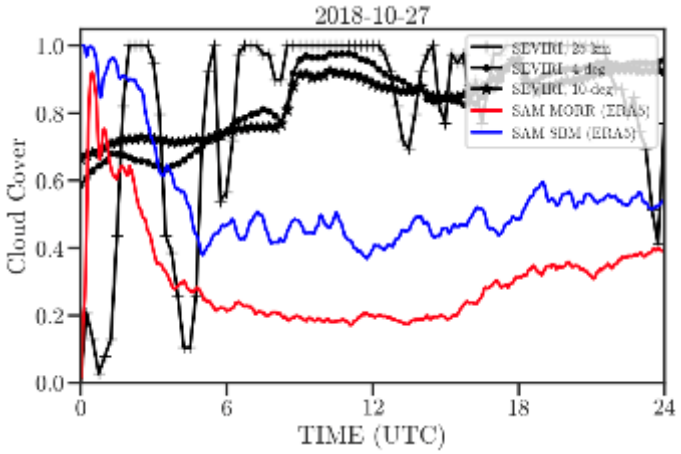
- Initial SAM runs
  - 25-km periodic domain; Δx=100 m
  - Morrison microphysics w/ specified droplet number
- Afternoons are particularly troublesome for closed-cell days

SAM Cloud Fraction Bias Versus SEVIRI



Thin marine cloud layers are quite finicky…

- Comparing two closed-cell days that have trouble with Morrison

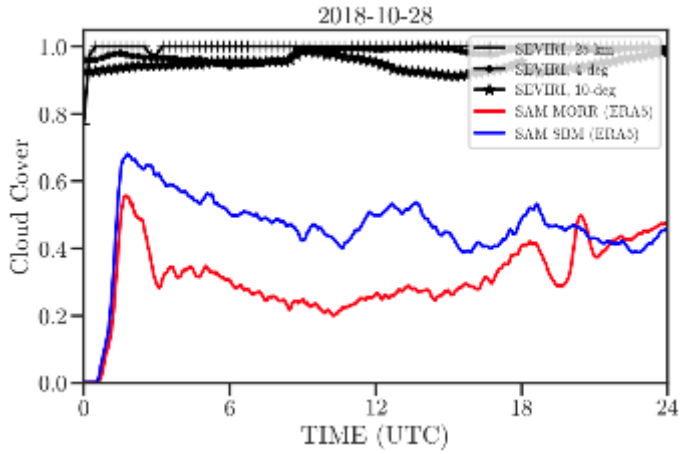


27-Oct-2018

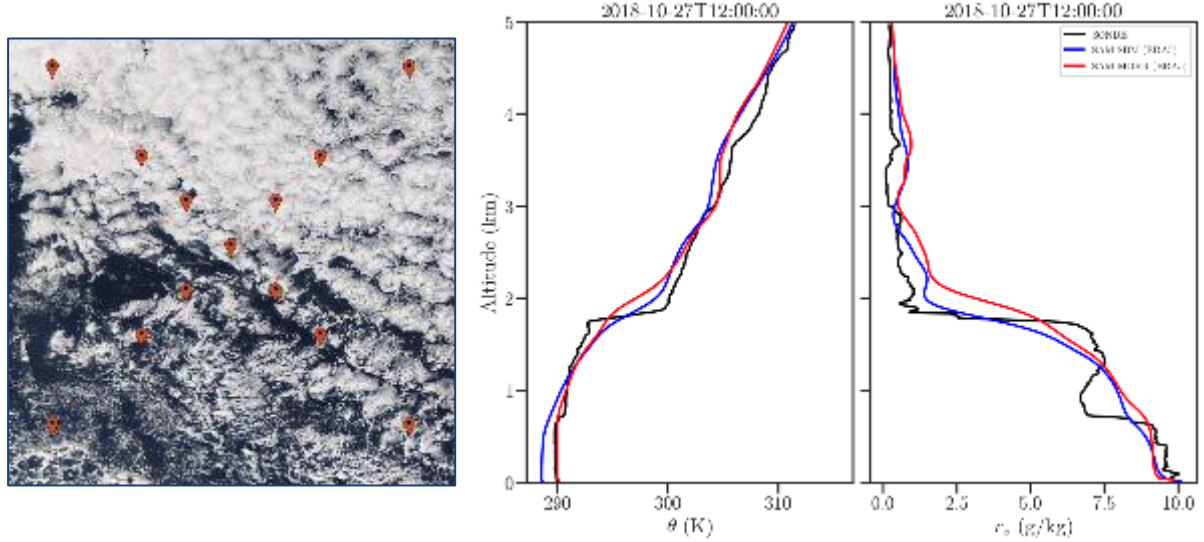
Red=Morrison

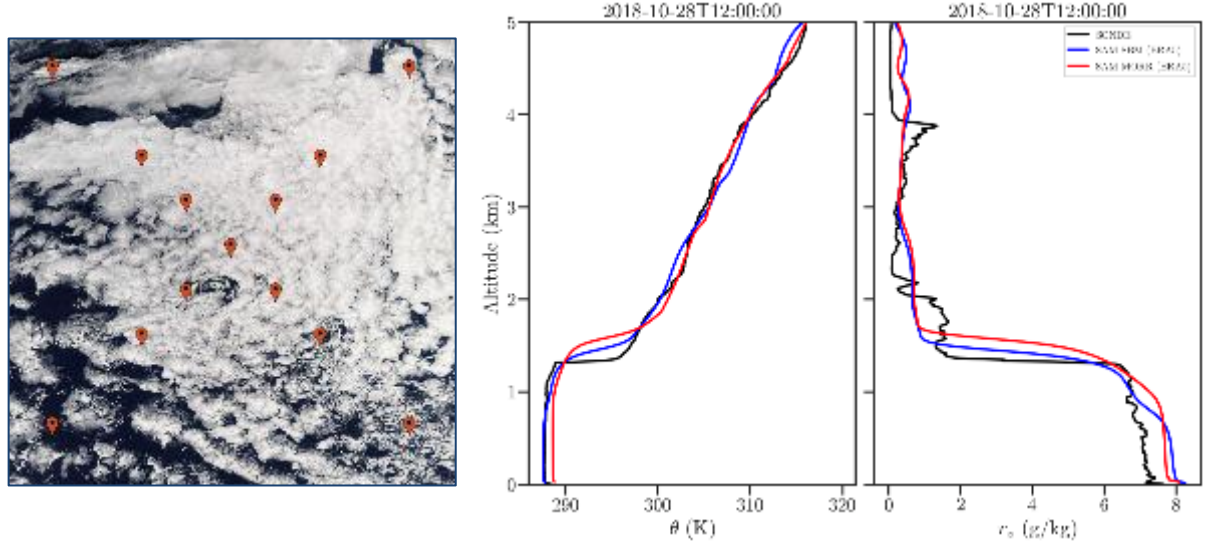
Blue=SBM

Black=Obs

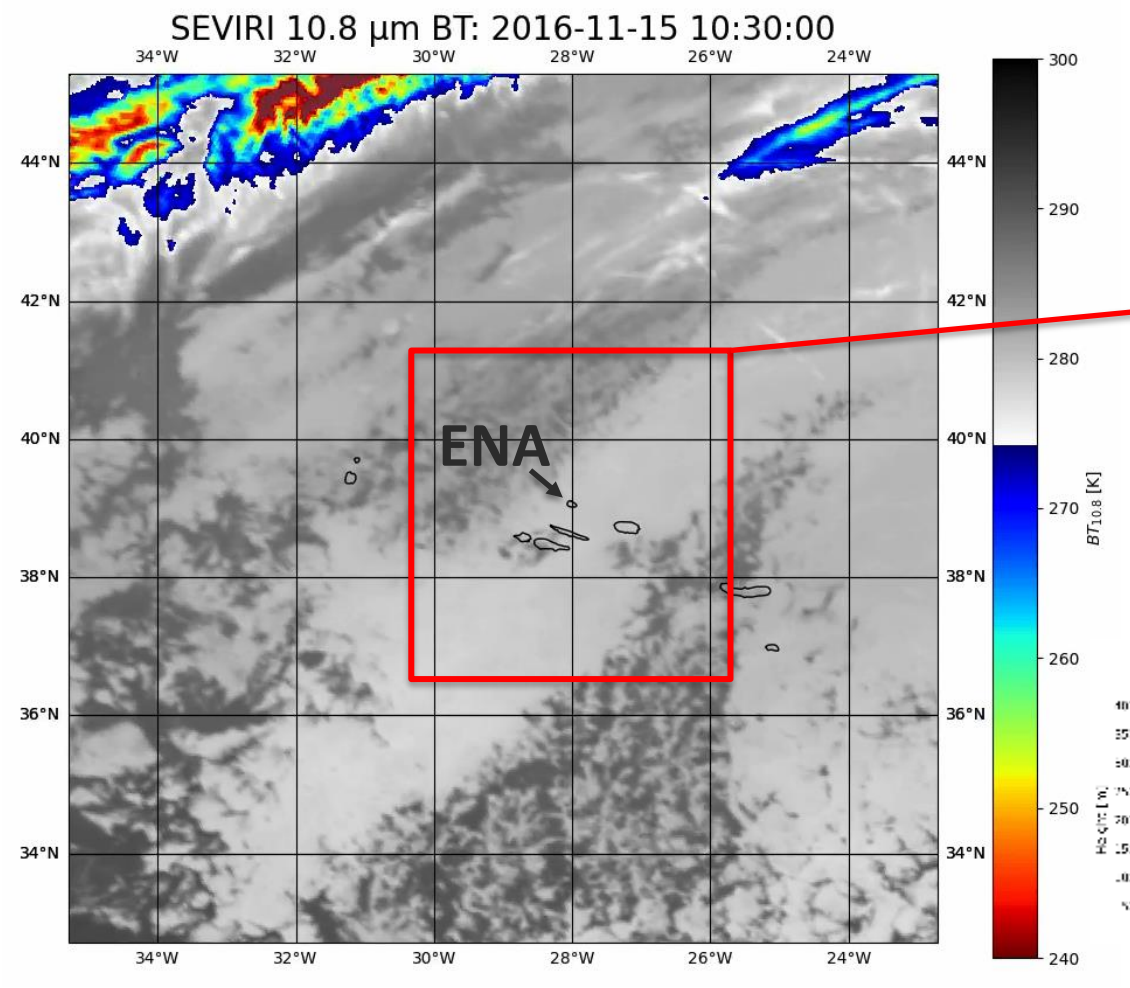


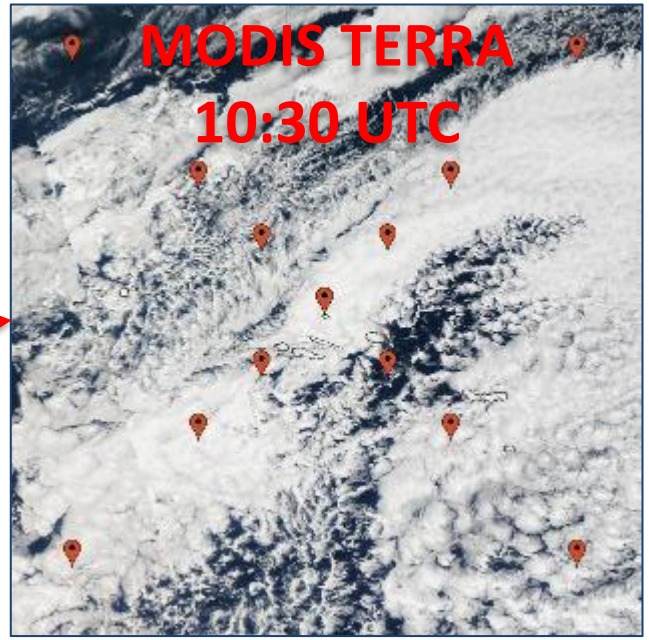
28-Oct-2018





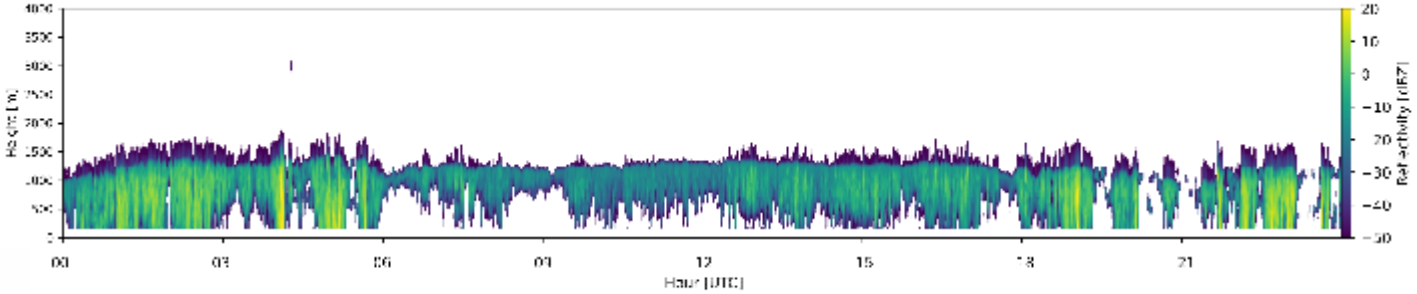
Case study for SBM: 15-Nov-2016





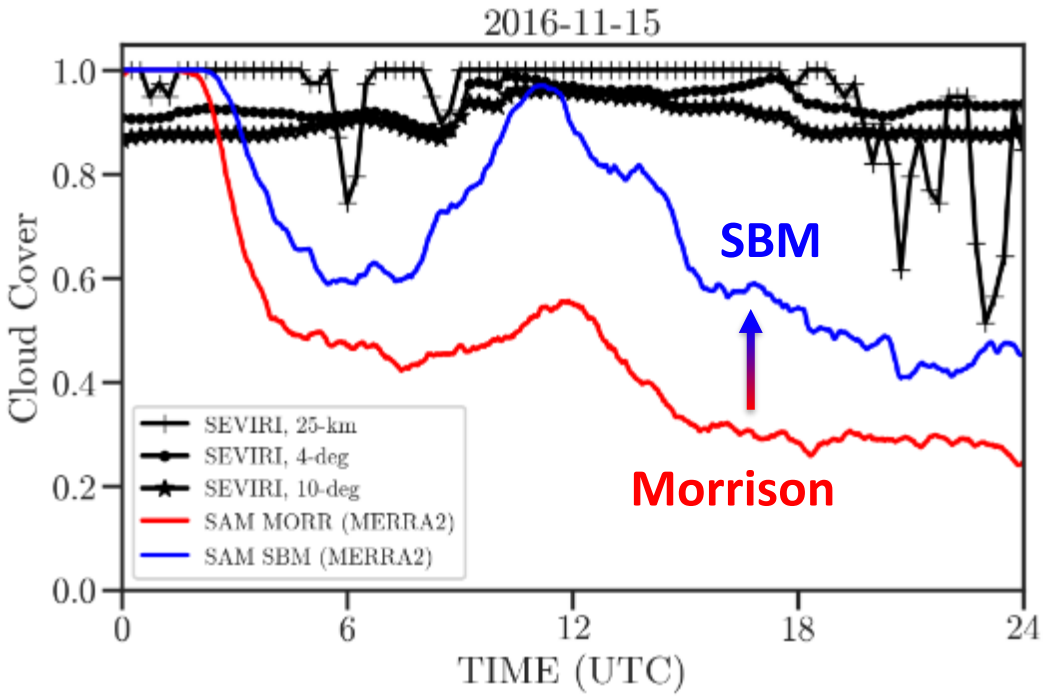
- Mostly overcast
- Virga and surface precip. are common
- Morphology changes as synoptic differences advect past ENA

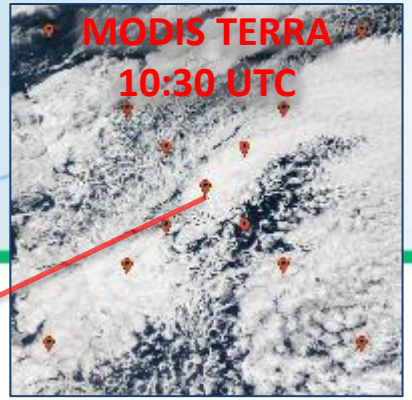
ARSCL Reflectivity at ENA



Impact of Spectral-Bin MP instead of Morrison

- Cloud fraction increases when using spectral-bin MP





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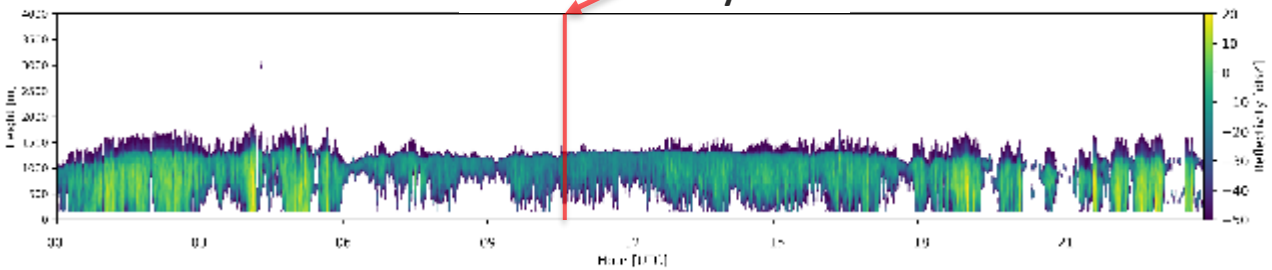
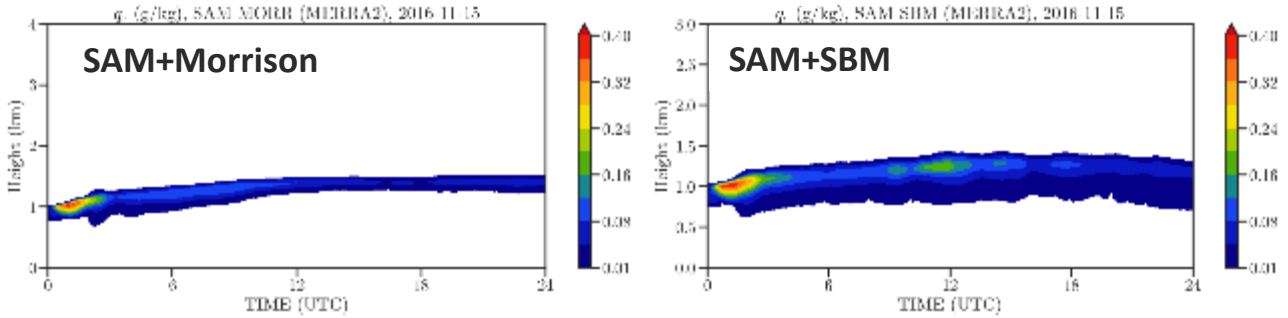
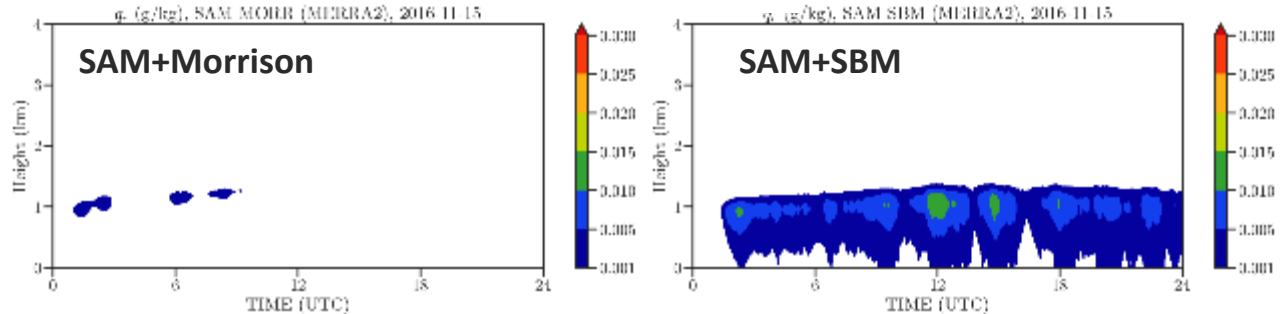


Cloud Water, Qc



Rainwater, Qr

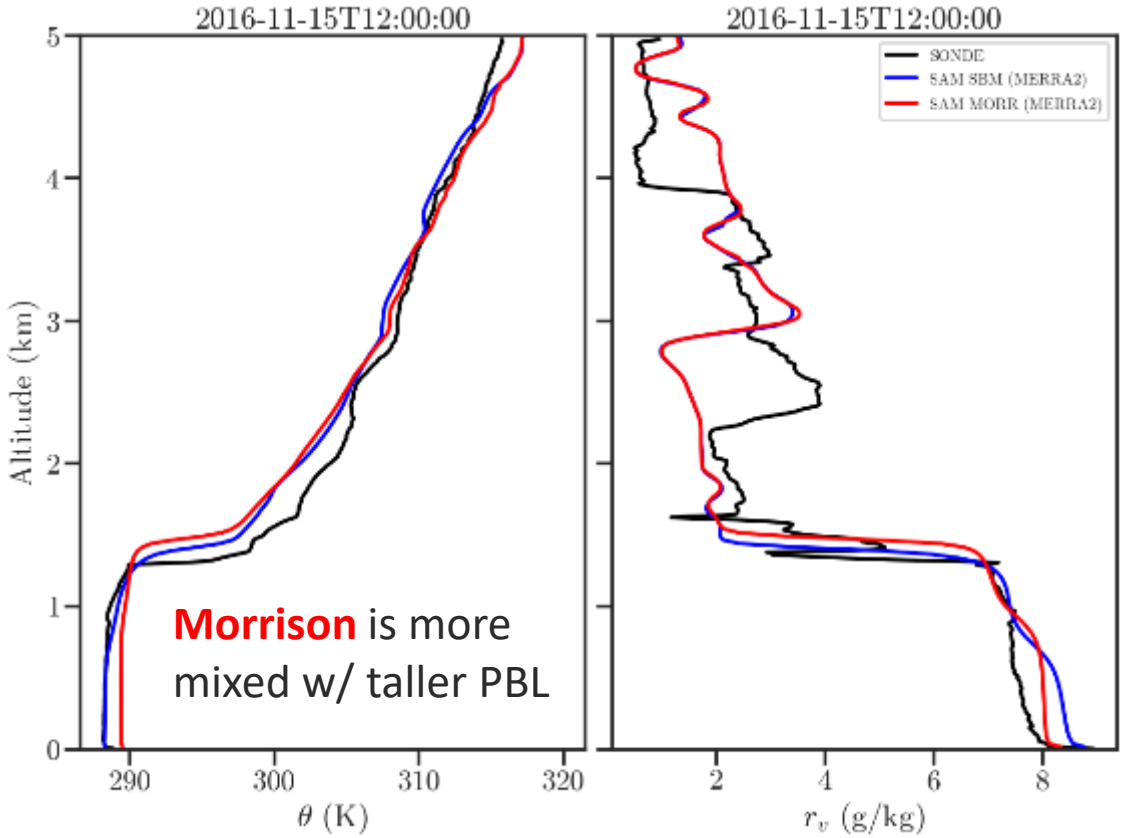


U.S. DEPARTMENT OF ENERGY

Spectral-Bin MP impact on thermodynamic profile

- Increased clouds due to SBM alter coupling to surface and often improve the profiles

15-Nov-2016 12 UTC (12 h into run)



16-Nov-2016 0 UTC (24 h into run)