INTERNATIONAL PACIFIC RESEARCH CENTER

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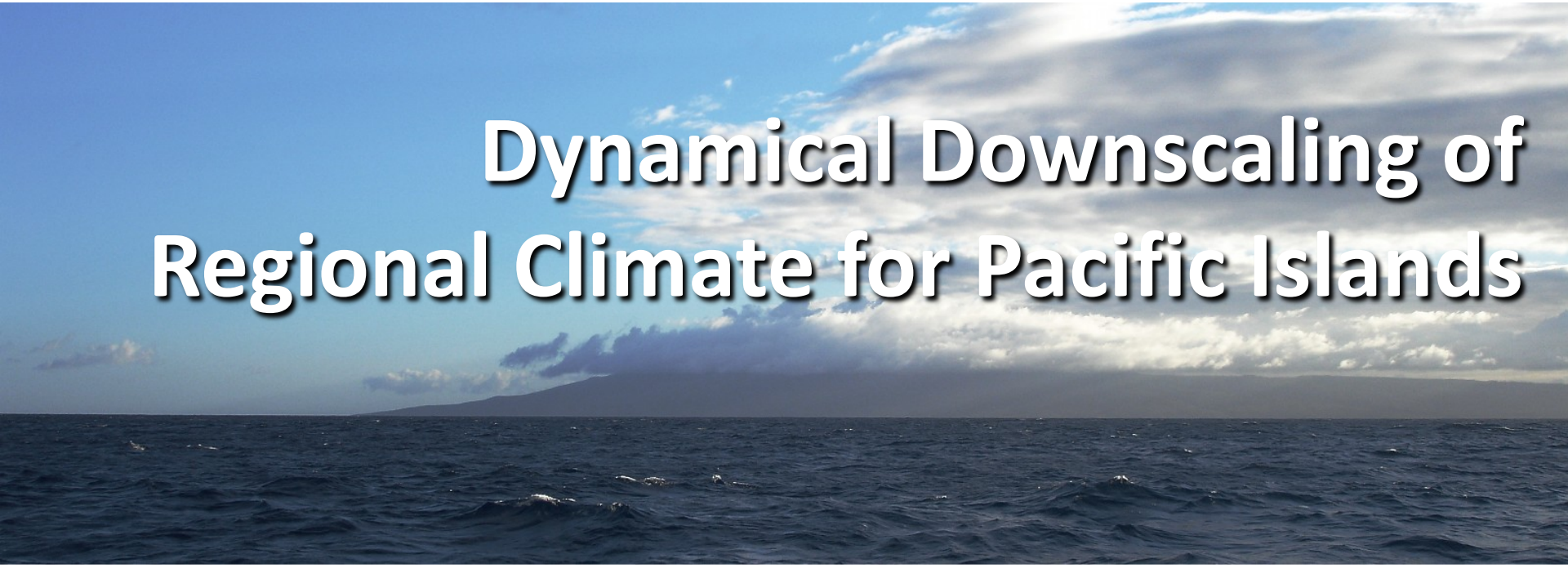
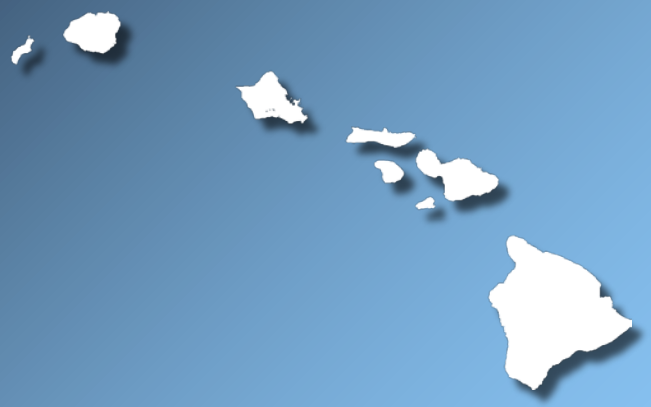


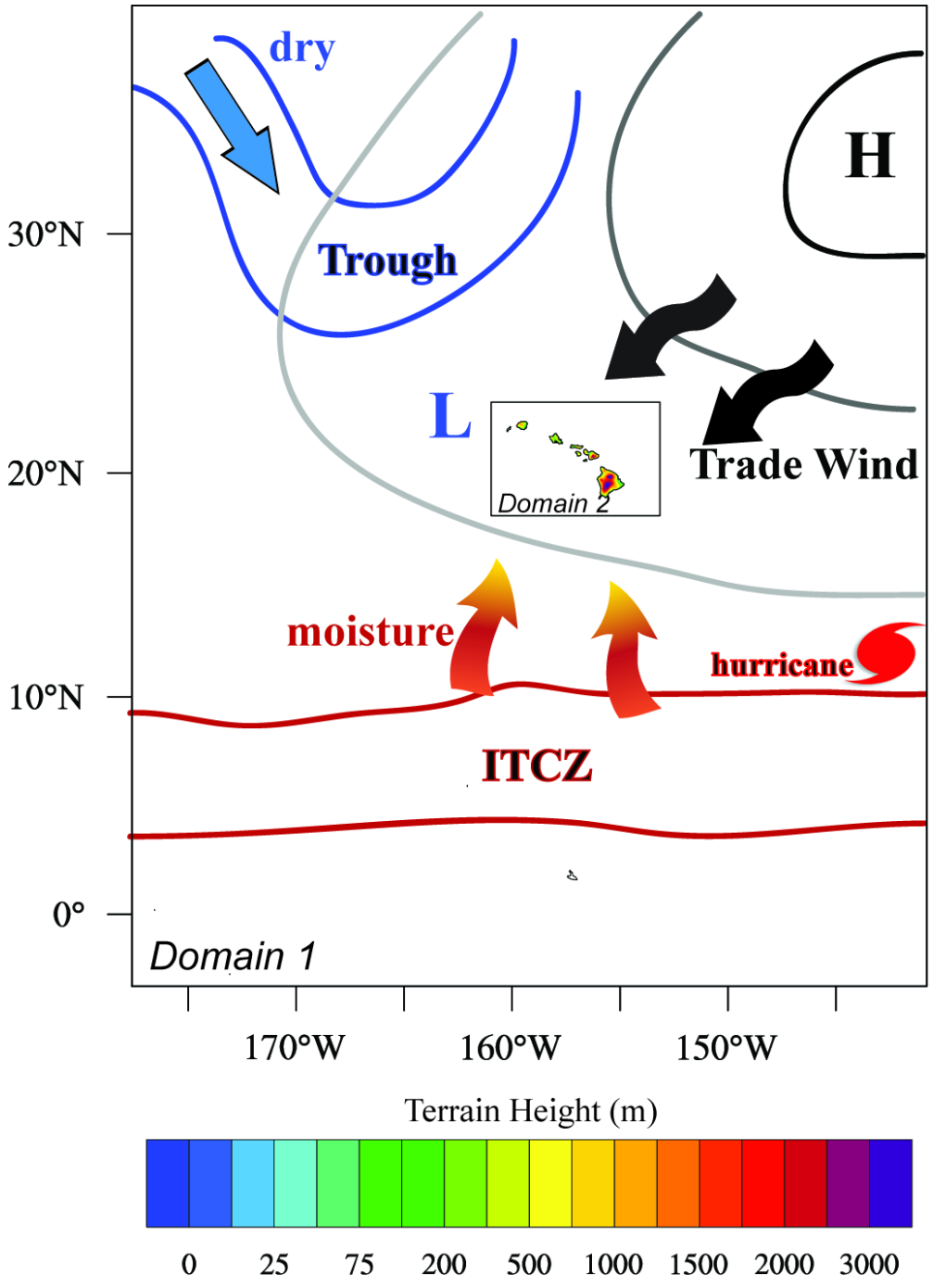
Dynamical Downscaling of Regional Climate for Pacific Islands

Dynamical downscaling of regional climate change in Hawaii

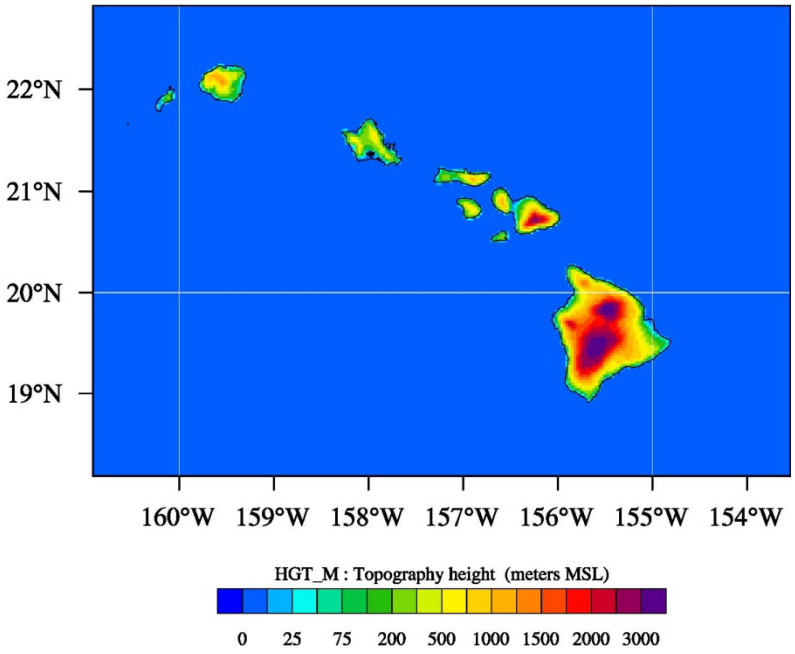


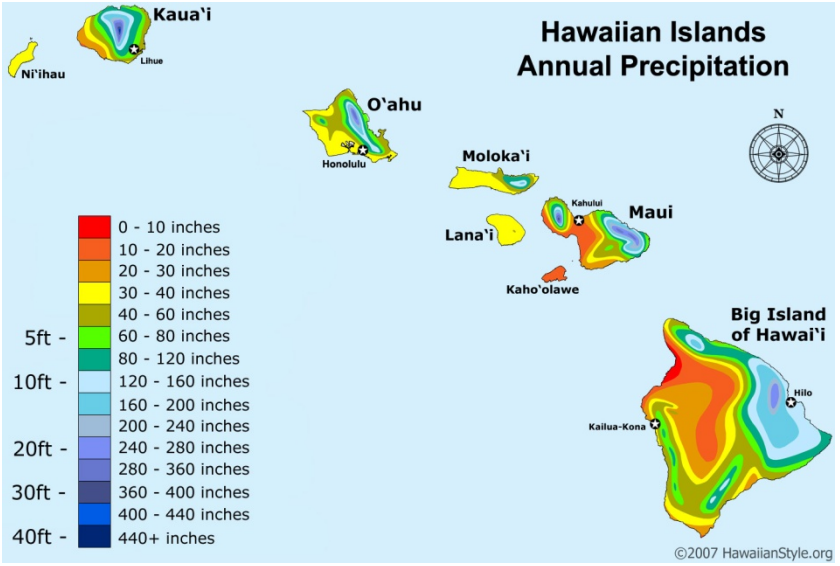
Outline

- The Hawaii Regional Climate Model (HRCM)
- Model evaluation
- Preliminary results
- Strategy and future plans



Terrain Height





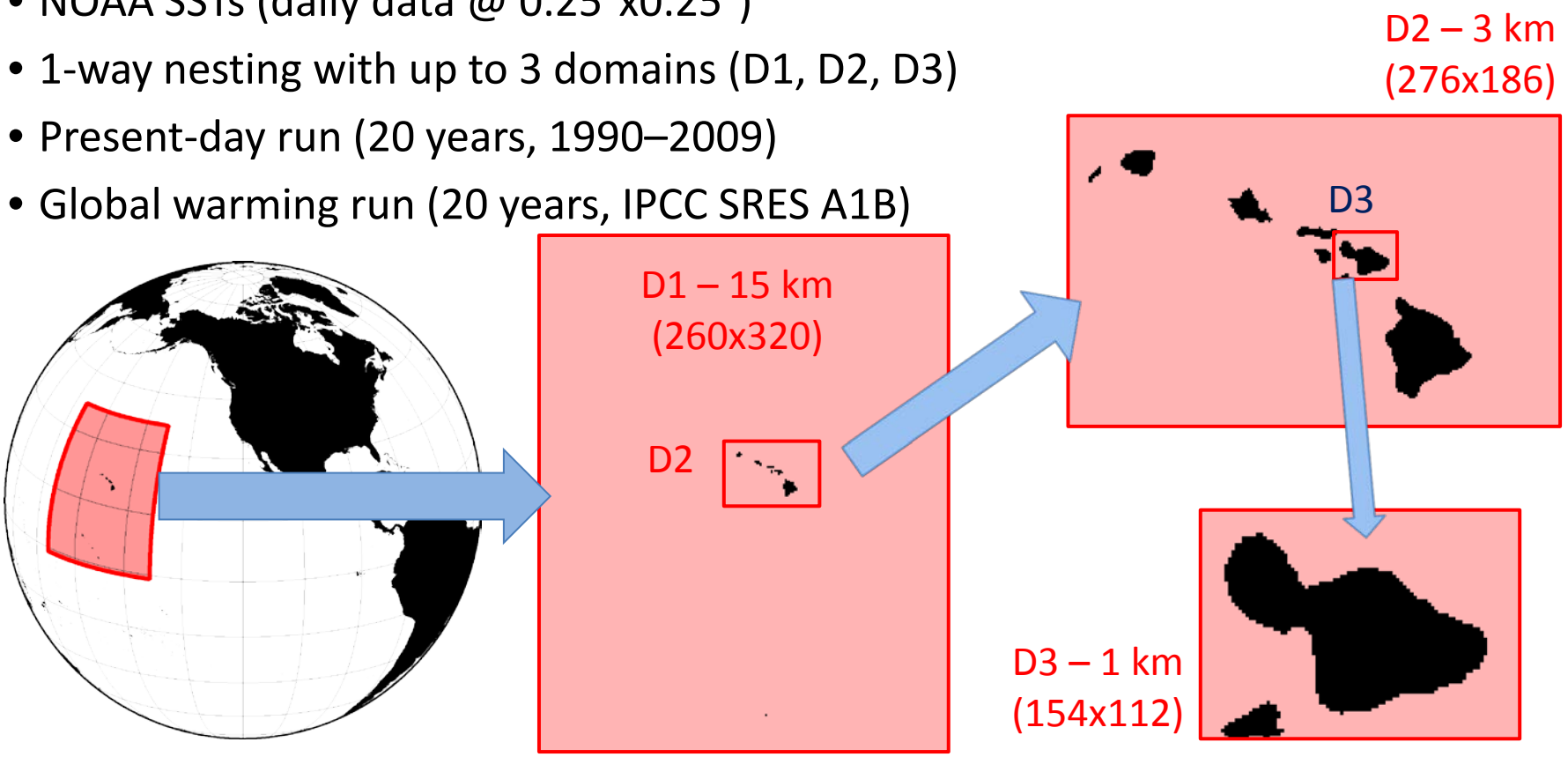
The Hawaii Regional Climate Model (HRCM)

Model Physics

- WRF version 3.3.1 (3.4.1 now)
- Mellor-Yamada- Janjić boundary layer scheme (MYJ)
- CAM radiation scheme (NCAR Community Atmosphere Model)
- Noah land surface model **with New Land Surface dataset**
- WRF Single-Moment 6-Class cloud microphysics scheme (WSM6), **modified for marine conditions**
- **Tiedtke cumulus convection scheme, implemented in WRF3.3** (mass flux scheme)

The Hawaii Regional Climate Model (HRCM)

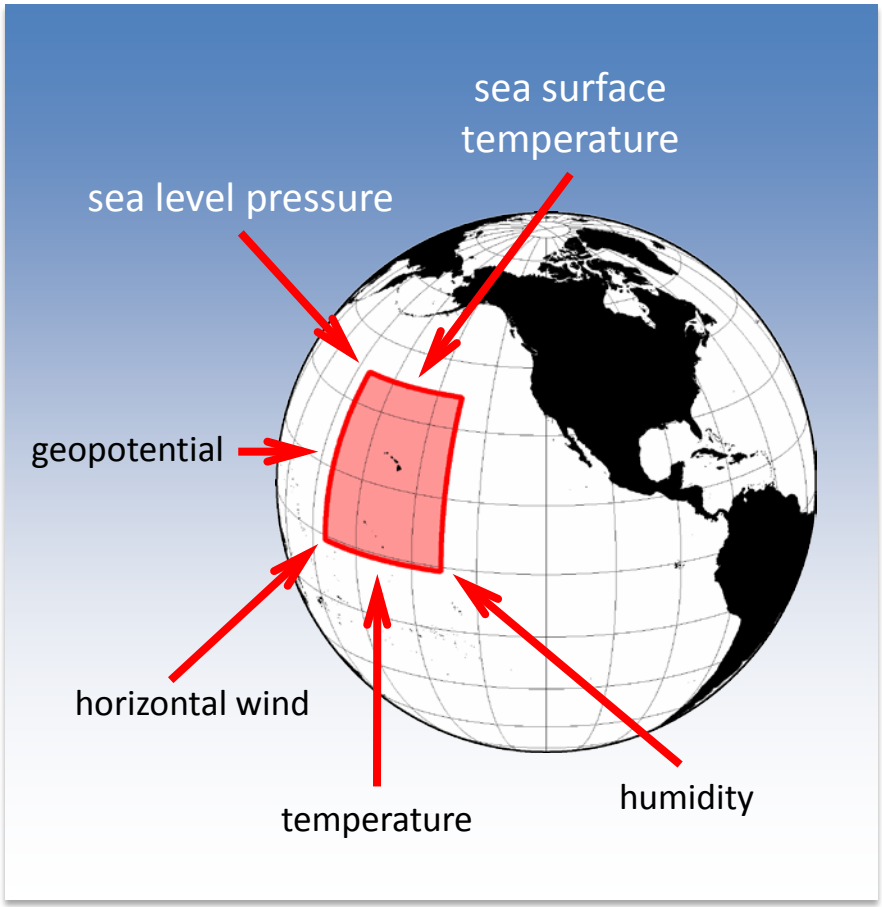
- 31 vertical levels (14 levels below 700 hPa)
- New data sets for: land cover/use (NLCD), surface albedo (MODIS), vegetation types/fraction and soil types (STATSGO2)
- MERRA (Modern-Era Retrospective Analysis for Research and Applications) reanalysis from NASA (6-hourly data @ 0.5°×0.67°)
- NOAA SSTs (daily data @ 0.25°x0.25°)
- 1-way nesting with up to 3 domains (D1, D2, D3)
- Present-day run (20 years, 1990–2009)
- Global warming run (20 years, IPCC SRES A1B)



Specification of the boundary conditions

Pseudo-Global-Warming Method

(*Kimura and Kitoh* 2007; *Sato et al.* 2007)



MERRA reanalysis data, NOAA SSTs

Present-day Run

MERRA reanalysis data, NOAA SSTs

+

Global warming increment (monthly means)

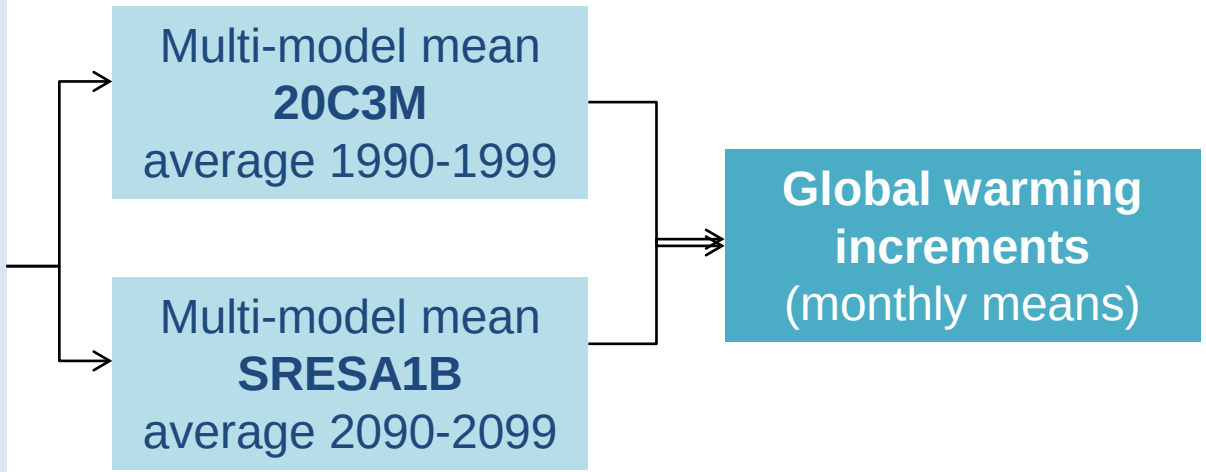
Global Warming Run

Specification of the boundary conditions

Pseudo-Global-Warming Method (*Kimura and Kitoh* 2007; *Sato et al.* 2007)

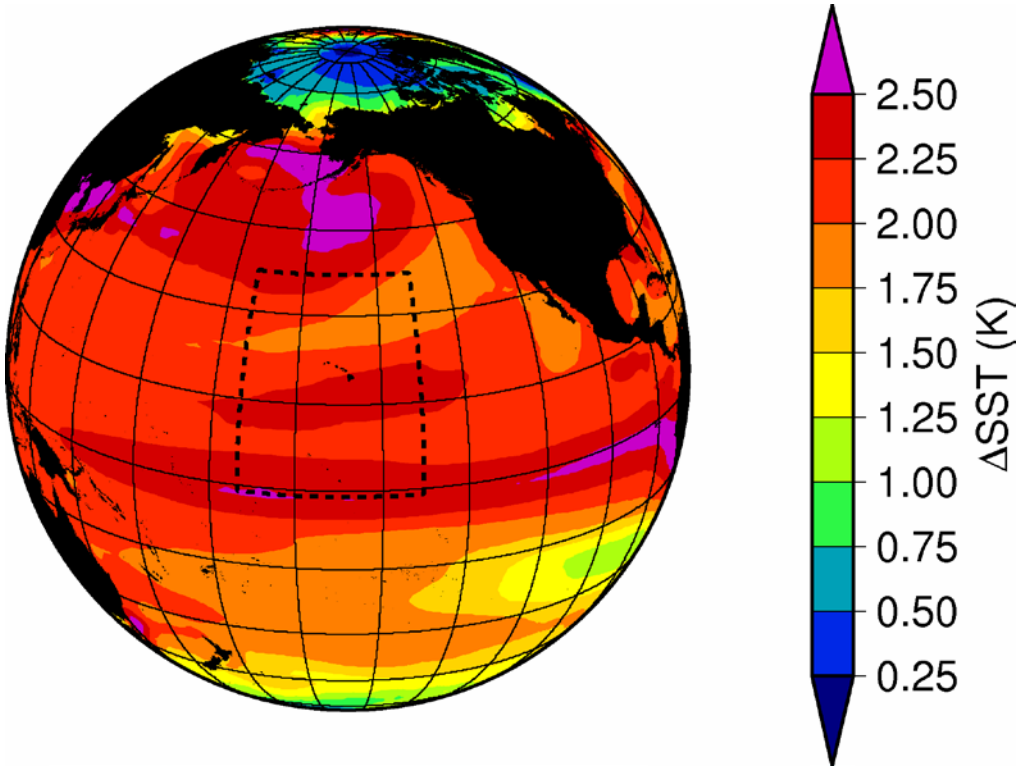
CMIP3 models

BCCr-BCM2.0
CGM3
CNRM-CM3
CSIRO-Mk3.0
CSIRO-Mk3.5
GFDL-CM2.0
GFDL-CM2.1
GISS-EH
GISS-ER
FGOALS-g1.0
INGV-SXG
INM-CM3.0
IPSL-CM4
MIROC3.2(hires)
ECHAM5/MPI-OM
MRI-CGCM2.3.2
CCSM3
PCM
UKMO-HadCM3
UKMO-HadGEM1



Global warming increment: SST

Future scenario (SRES A1B, 2090-2099) – present-day (20C3M, 1990-1999)



Multi-model mean (16 CMIP3 models)

New Land Surface Data

- **(1) Green Vegetation Fraction (GVF)**

  Old: NESDIS/NOAA 0.144 degree monthly 5- year climatology.

  New: MODIS 1 minute 16days 5-year climatology (2000-2004). Derived from MODIS NDVI climatology, and averaged to monthly mean.

  the formula: (GVF=NDVI-0.04)/(NDVImax-0.04)

- **(2) ALBEDO**

  Old: NESDIS/NOAA 0.144 degree monthly 5-year climatology

  New: MODIS 1 minute 16days 5-year climatology (0.3-5.0μm black and white sky averaged). Some missing points are fixed by MODIS land cover/use data, totally less than 5%.

New Land Surface Data

- **(3) Soil types**

  Old: FAO global 5 minute

  New: STATSGO 30 second shape data.

  We convert to grid format and made some type conversion.

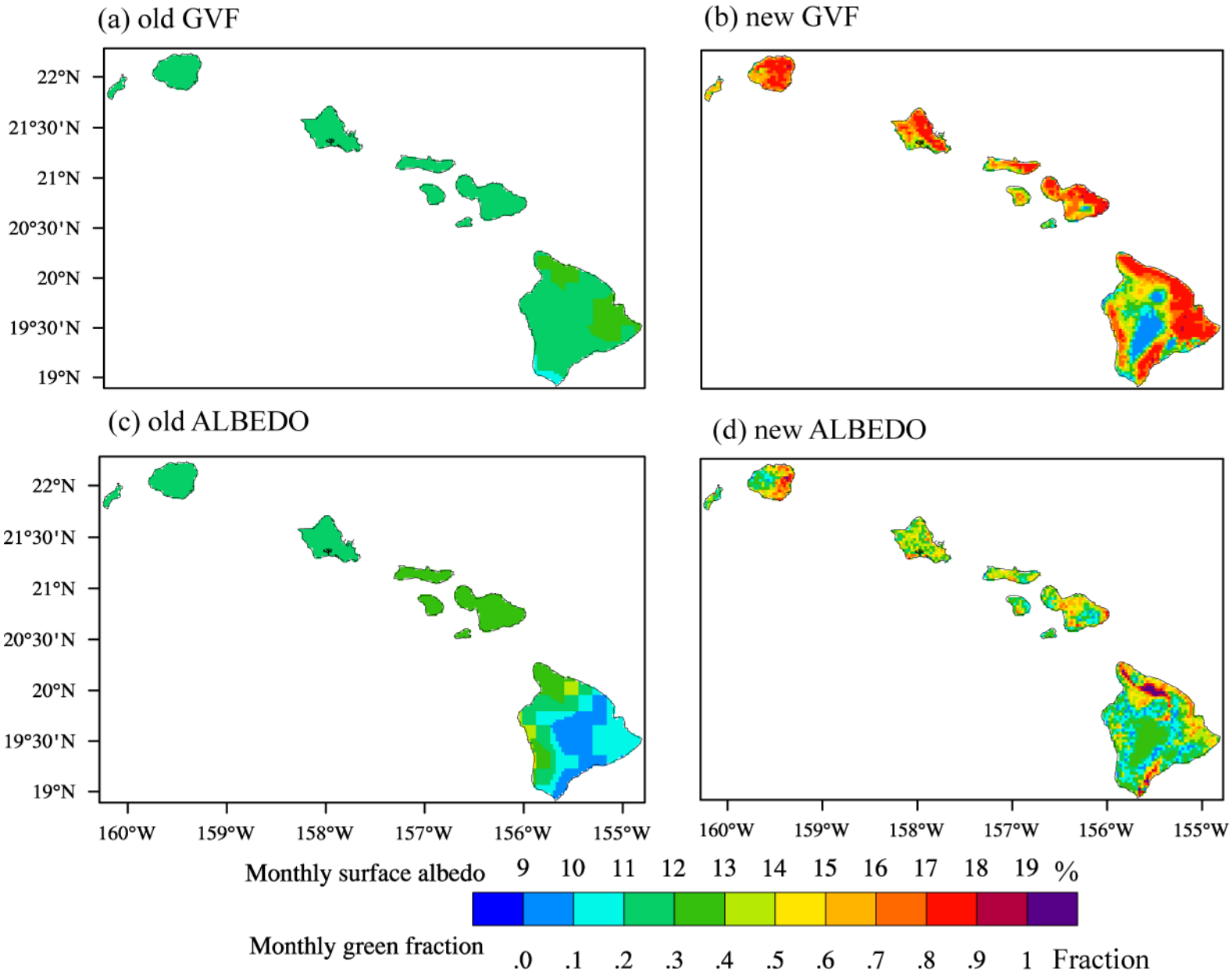
- **(4) Land cover/use data**

  Old: USGS 30s

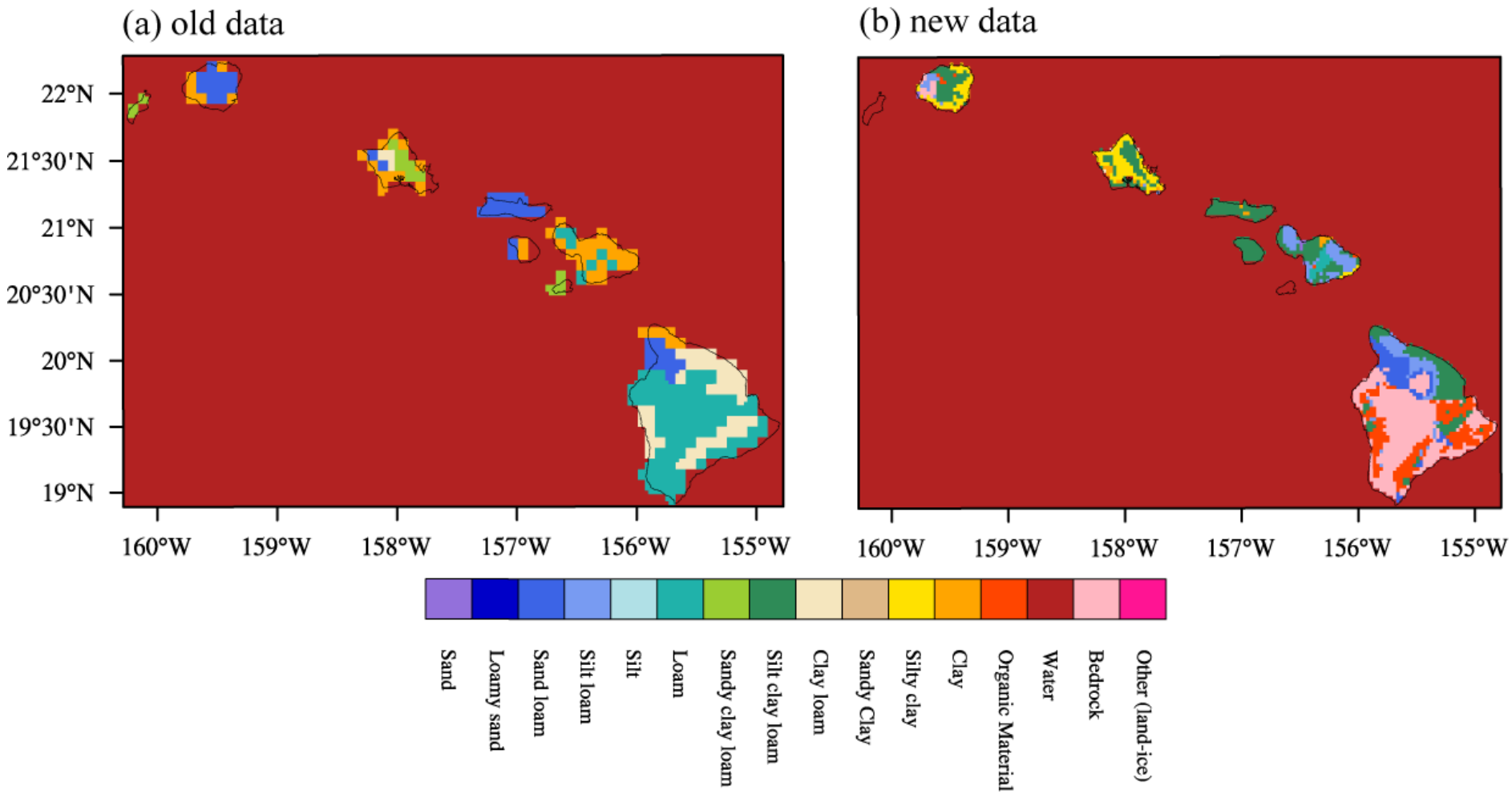
  New: NLCD 1s

  Some conversion between the NLCD categories to the USGS 24 categories is needed. For example, in NLCD, urban has 4 categories, while only one category in USGS.

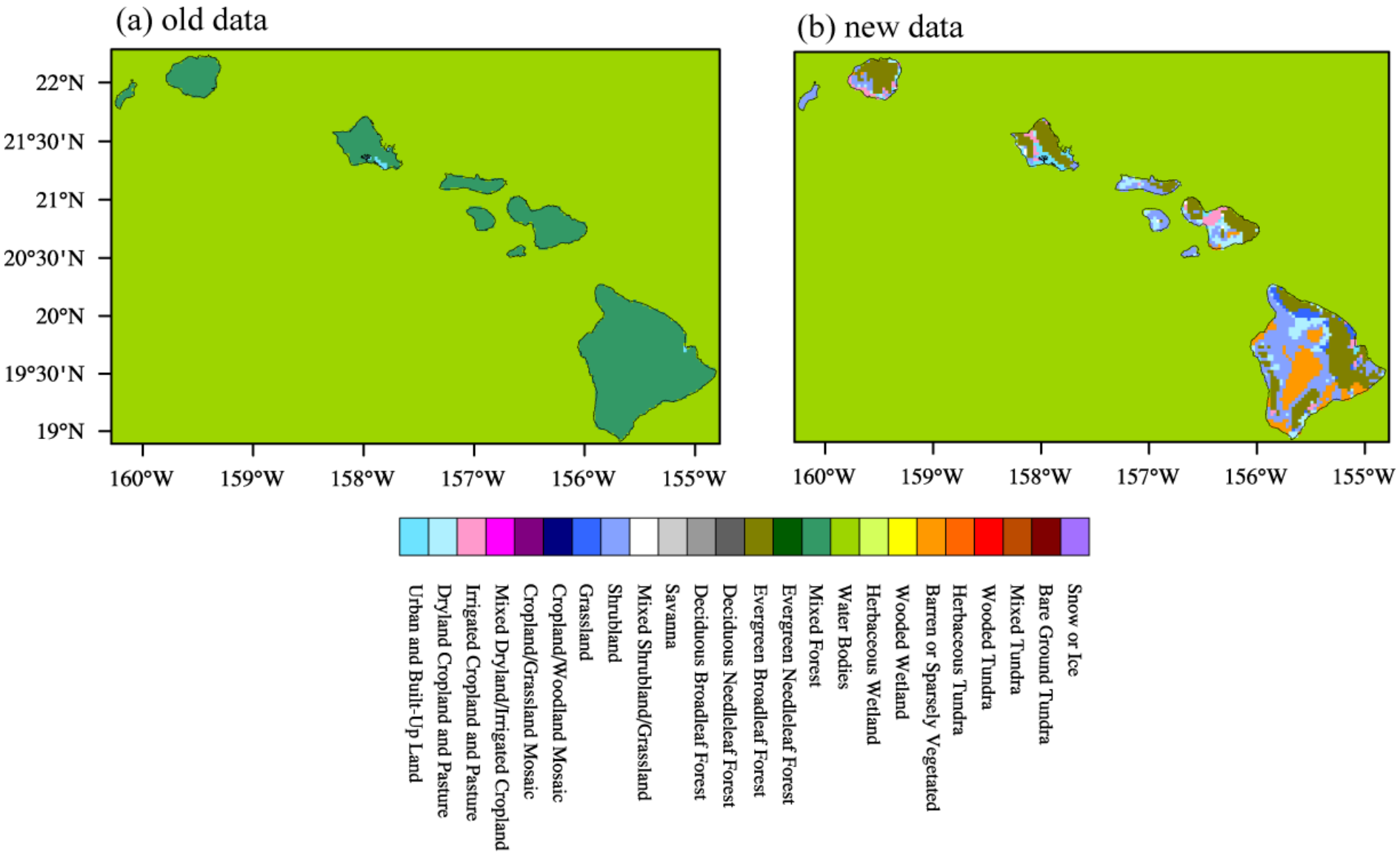
Green vegetation fraction & ALBEDO in July



Top layer soil types



Land cover/use

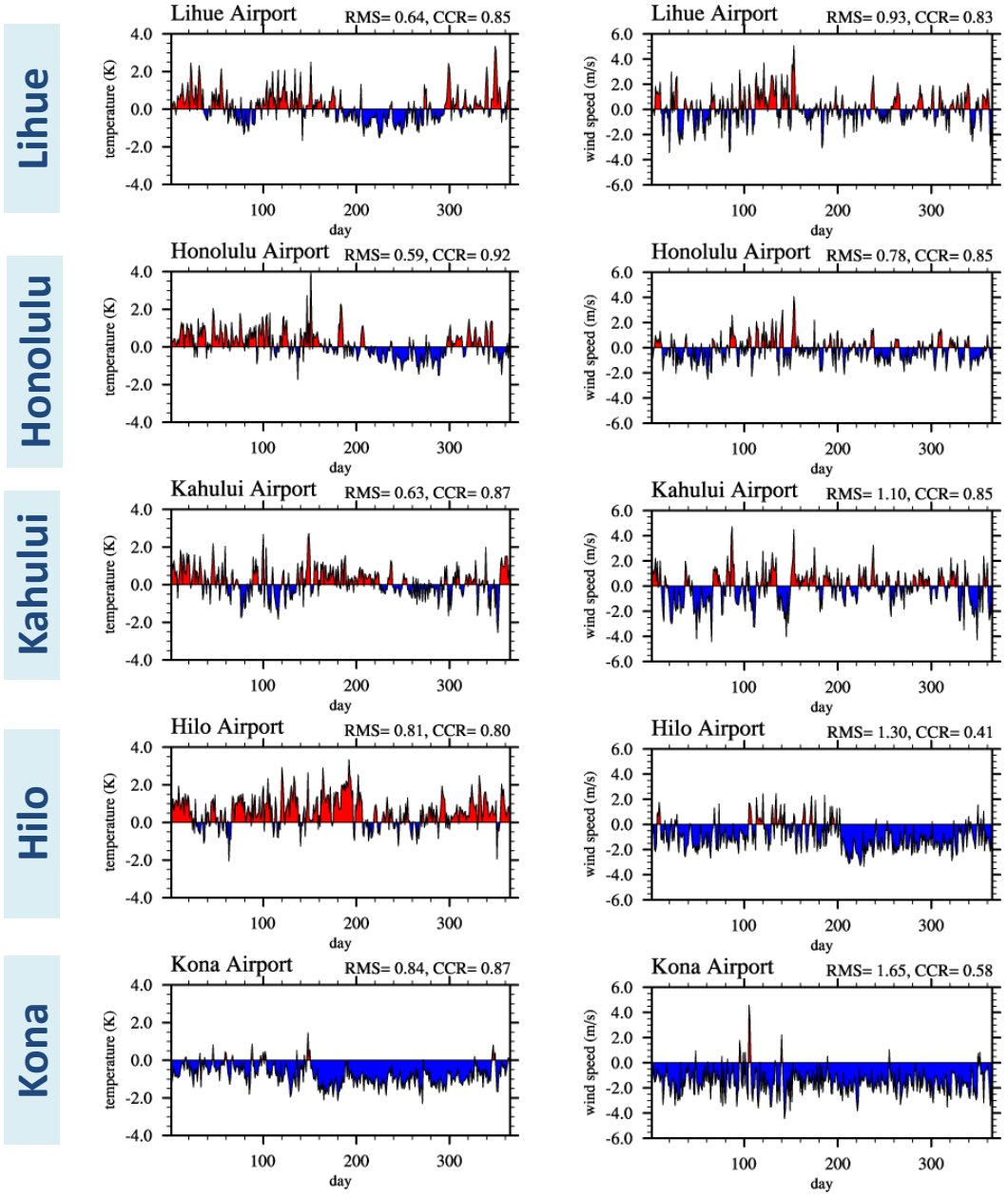


Model Evaluation

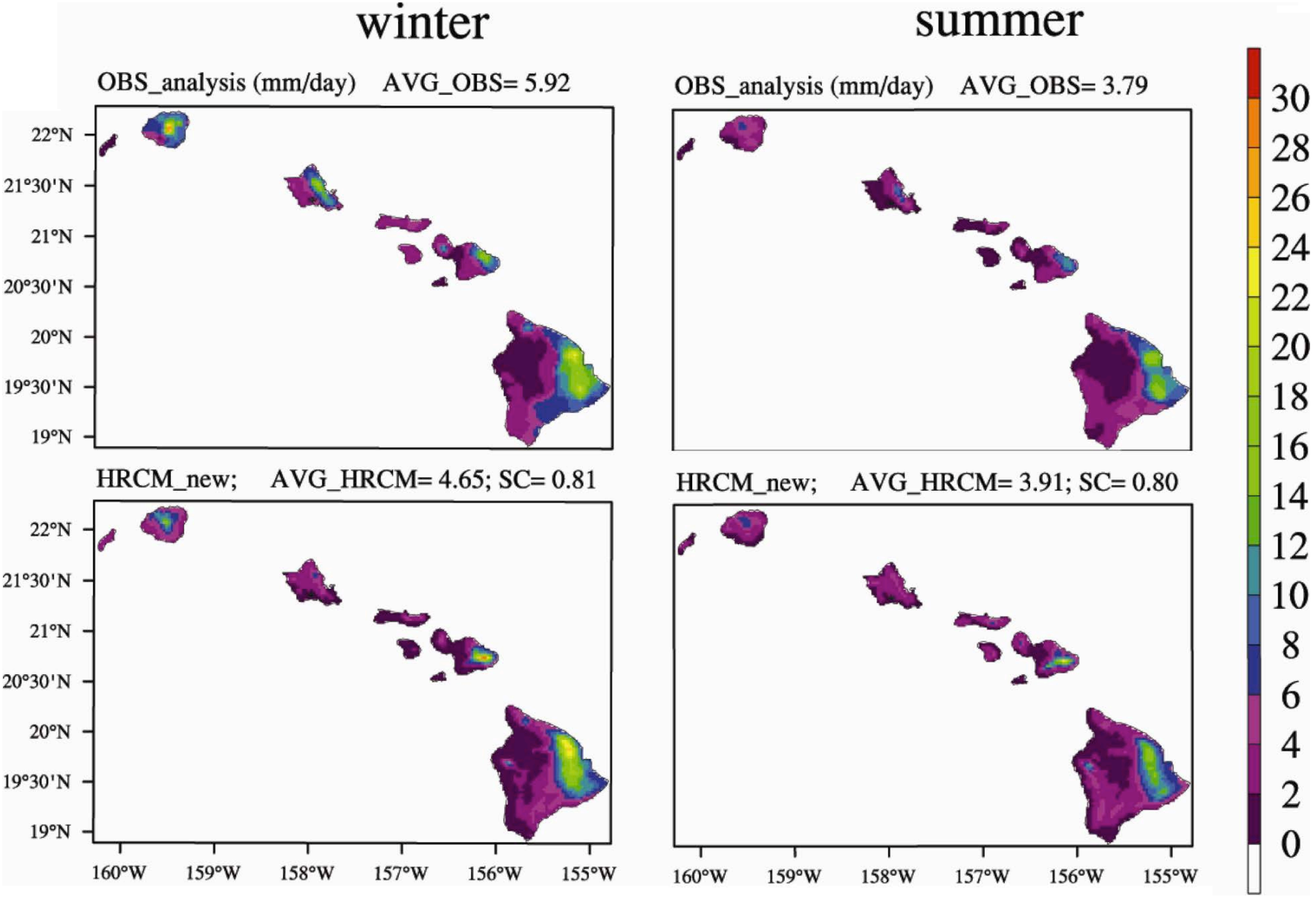
Model domain D2 (3 km)

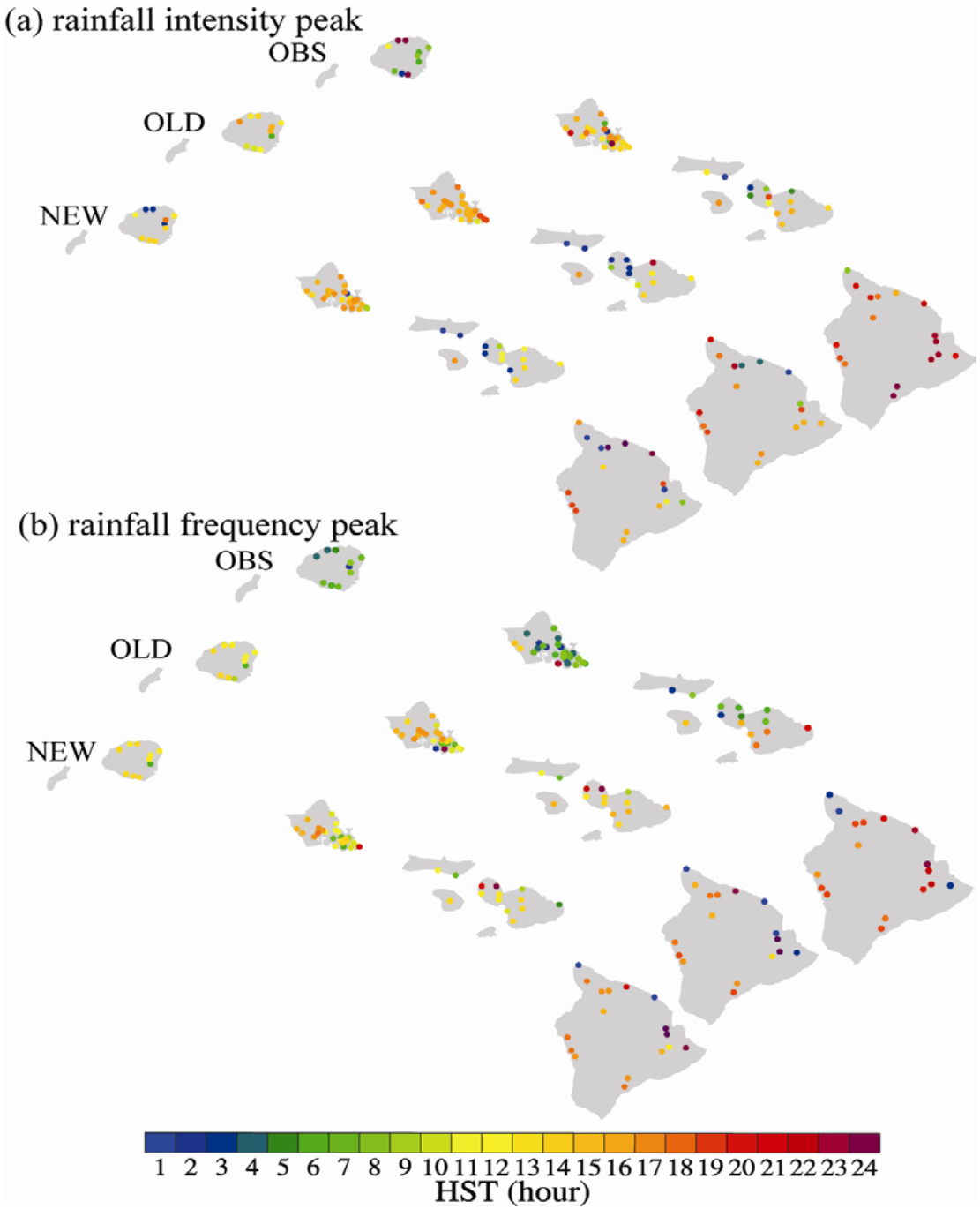
Year 2006

2-m temperatures and 10-m wind speed in 2006



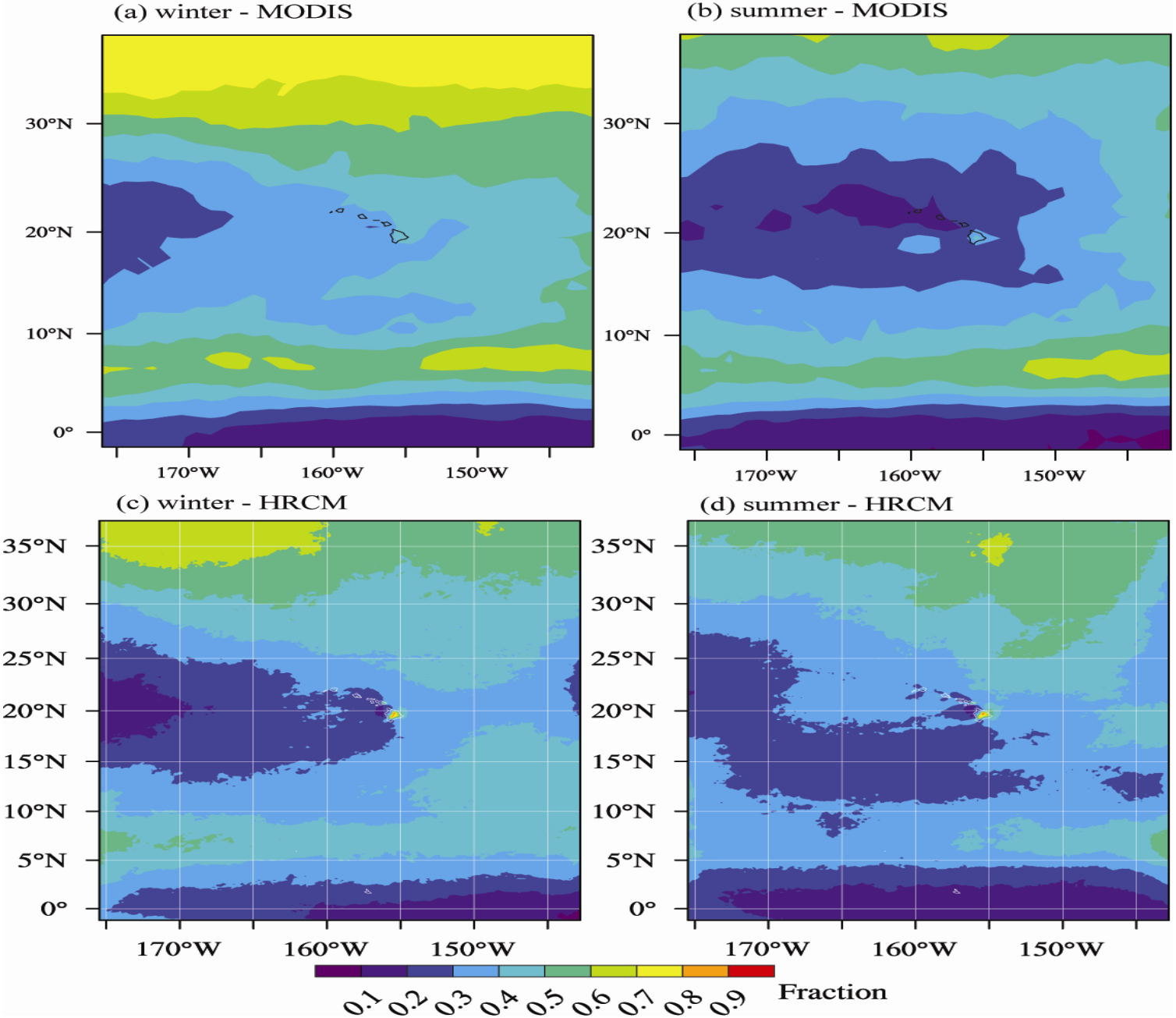
Seasonal mean precipitation in 2006 (mm per day)





Rainfall intensity and frequency peak in diurnal cycle

Seasonal mean cloud fraction in 2006

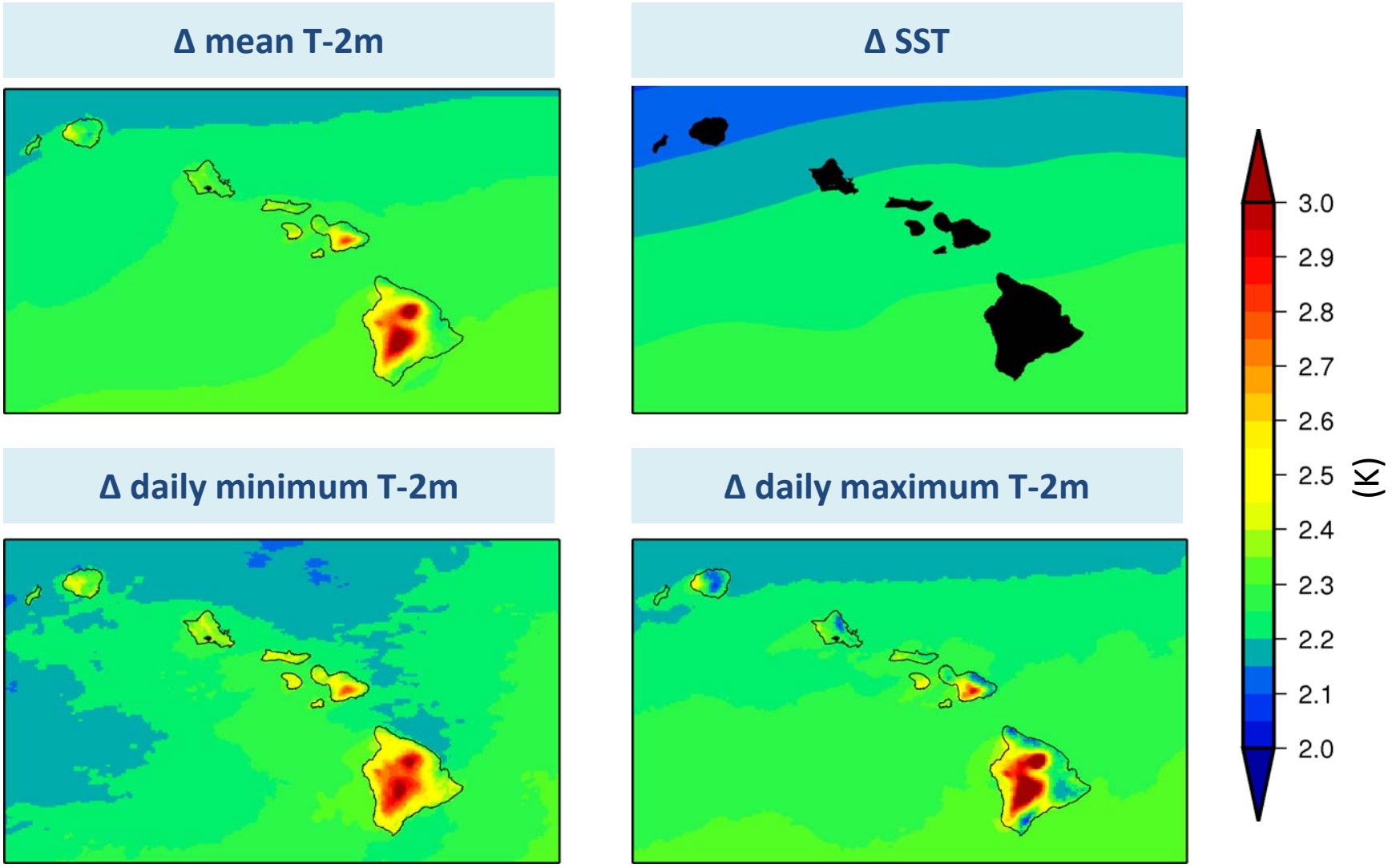


Preliminary HRCM results (1)

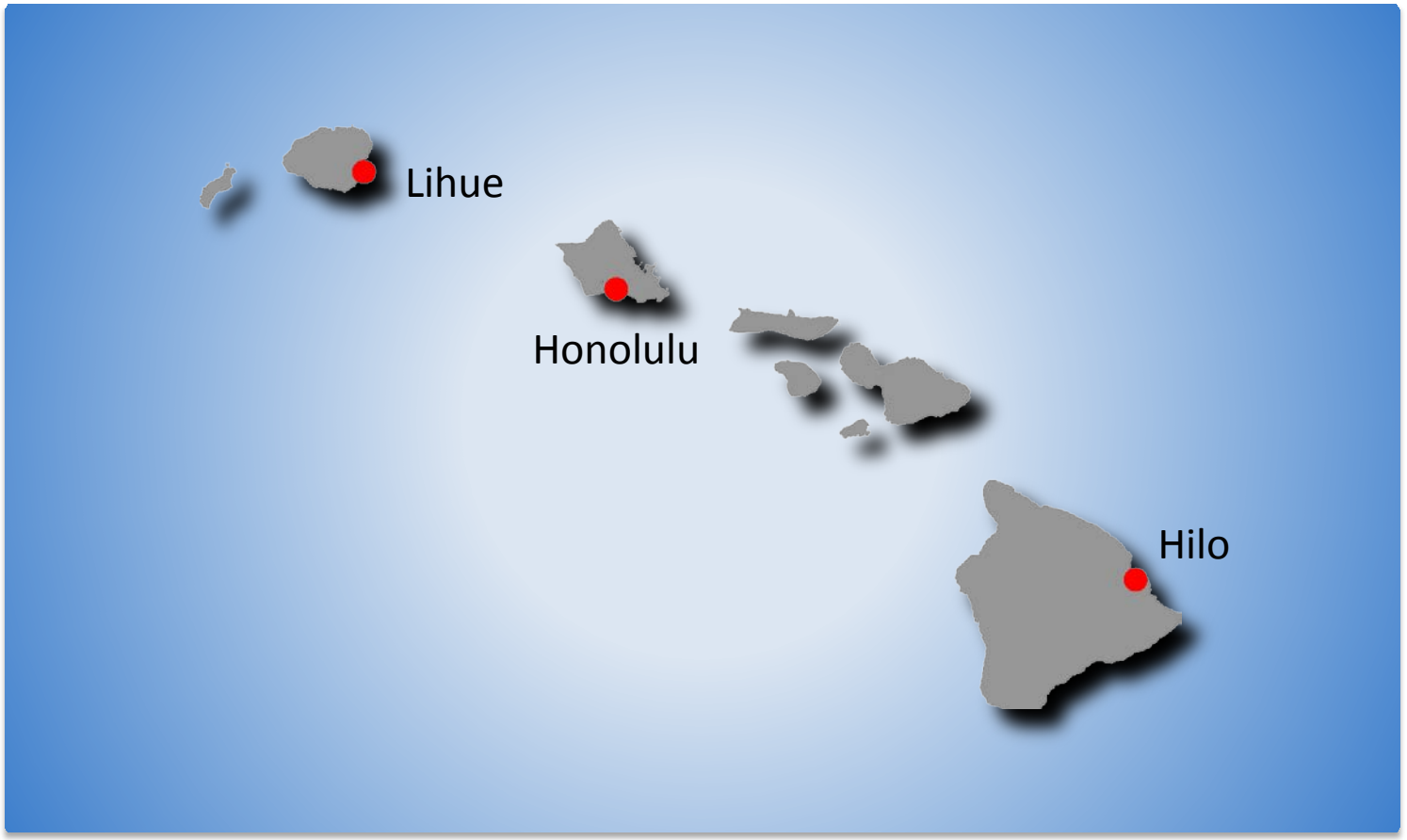
Model domain D2 (3 km)

8-year means (1990-1997)

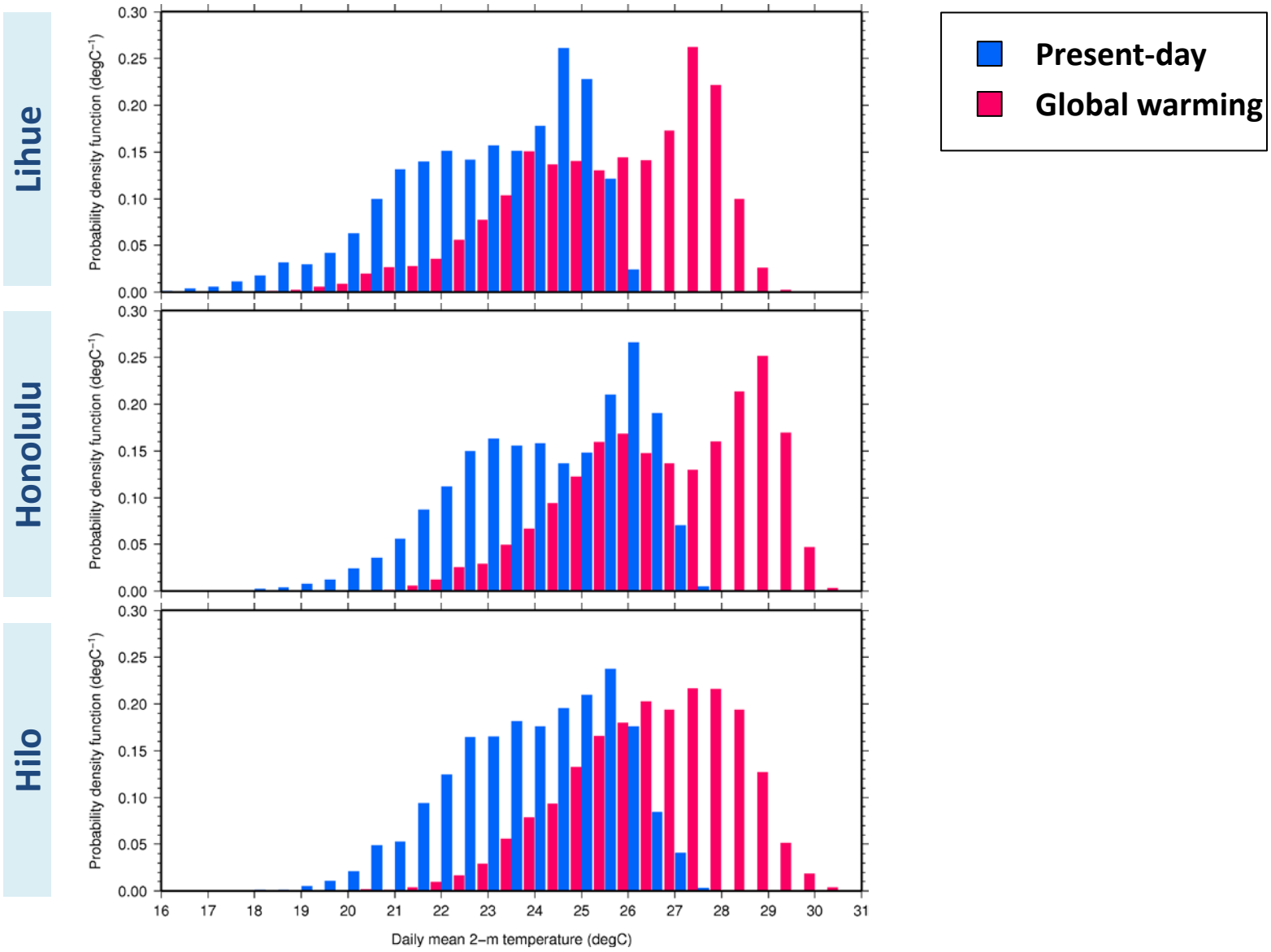
Annual average changes in 2-m temperatures (K)



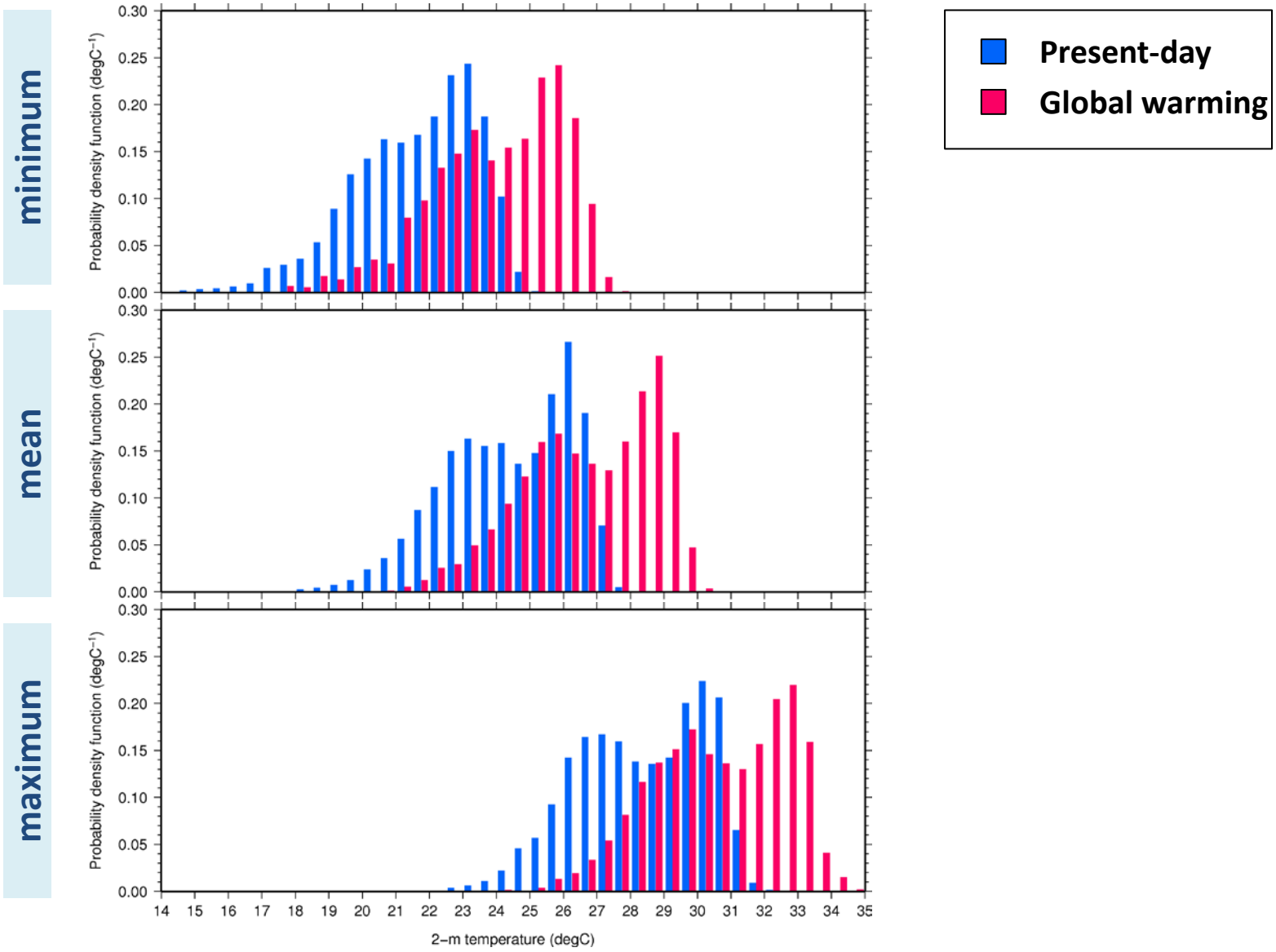
Probability density function of 2-m temperatures



PDFs of daily mean 2-m temperatures

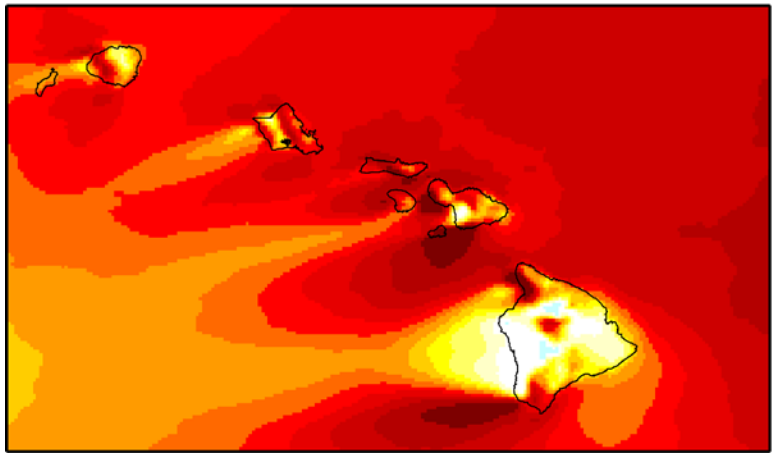


PDFs of Honolulu 2-m temperatures

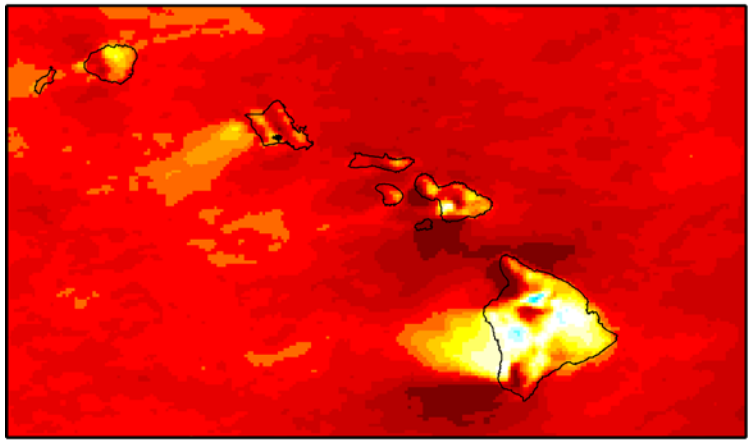


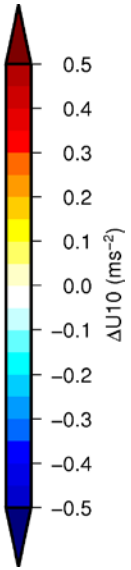
Annual average changes in 10-m wind speed (ms^{-1})

Δ mean U10



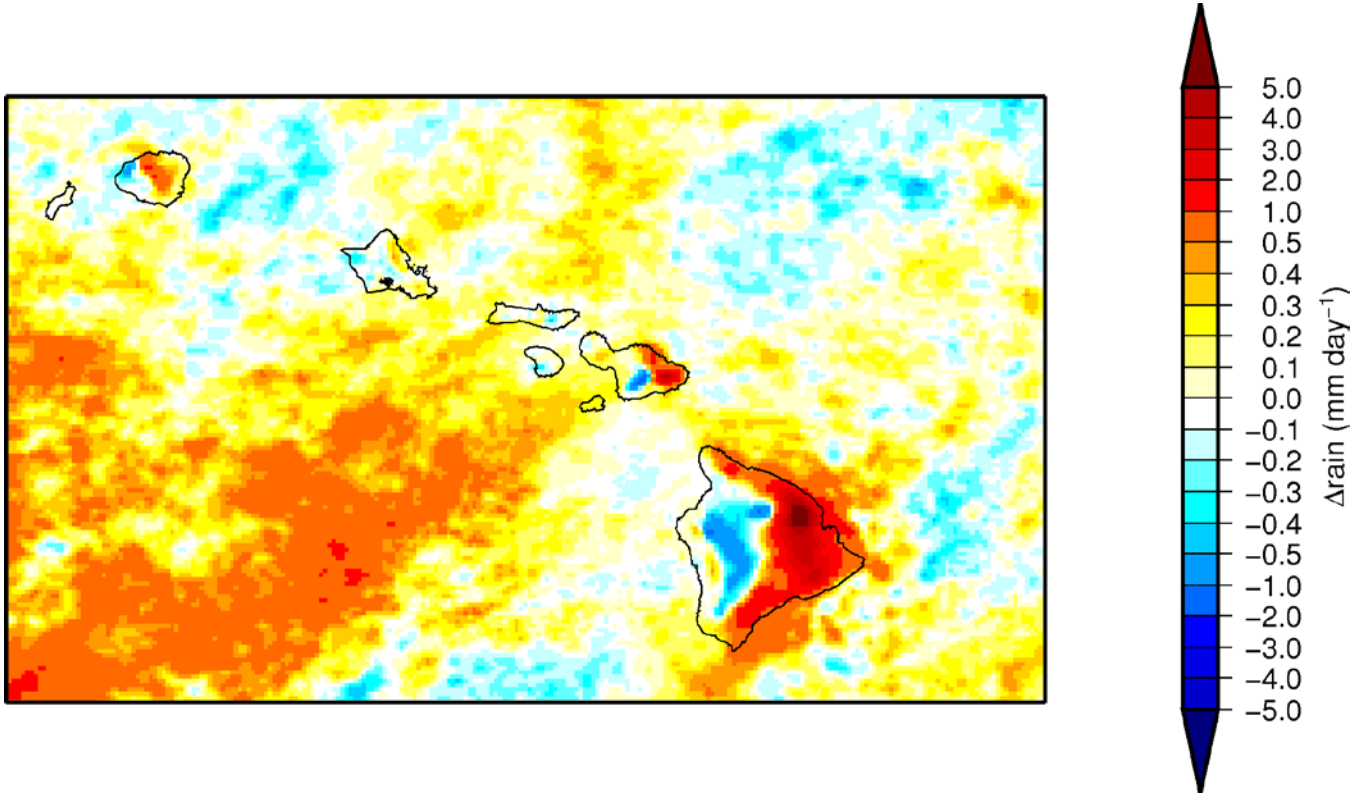
Δ daily maximum U10



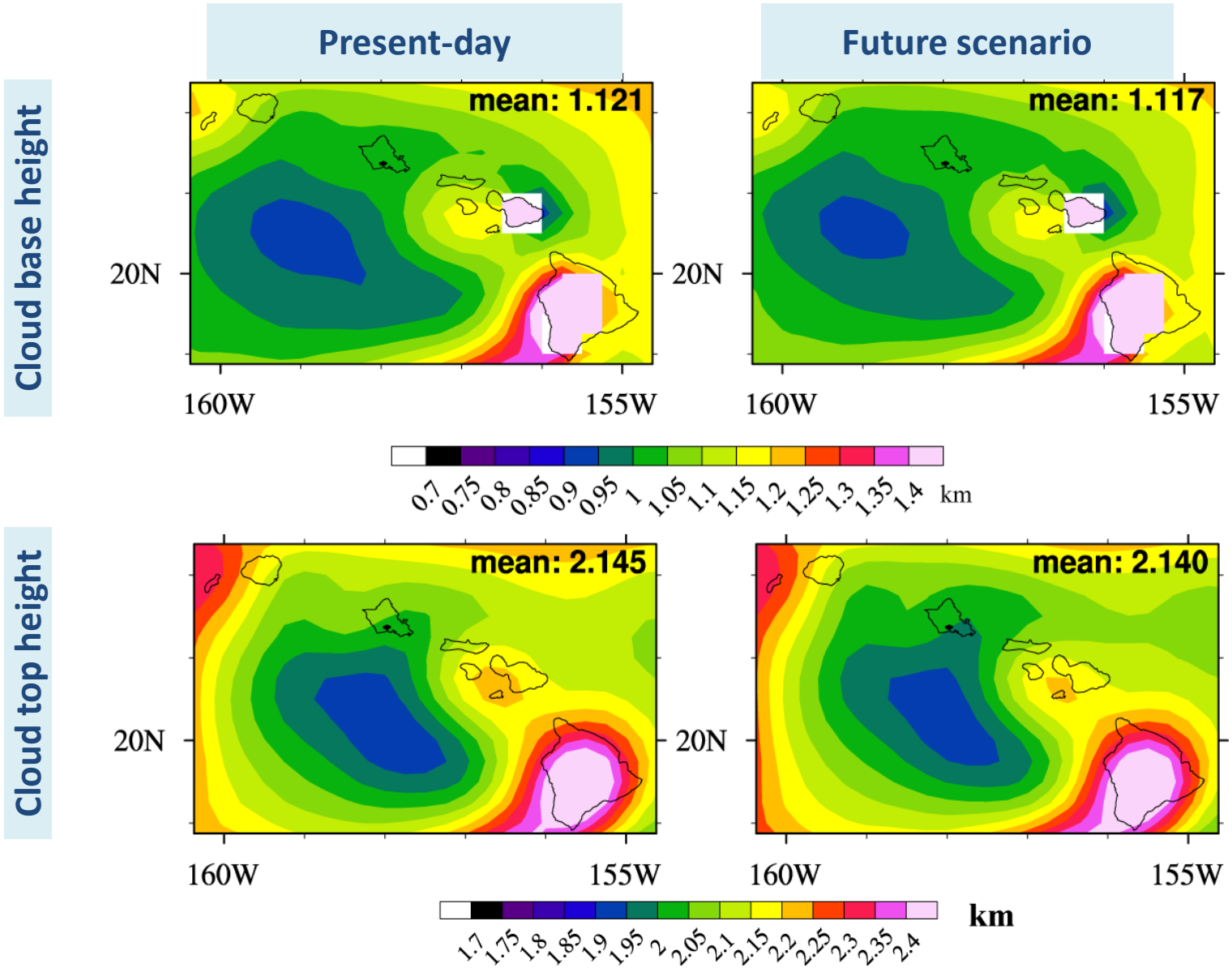


Annual average changes precipitation (mm day^{-1})

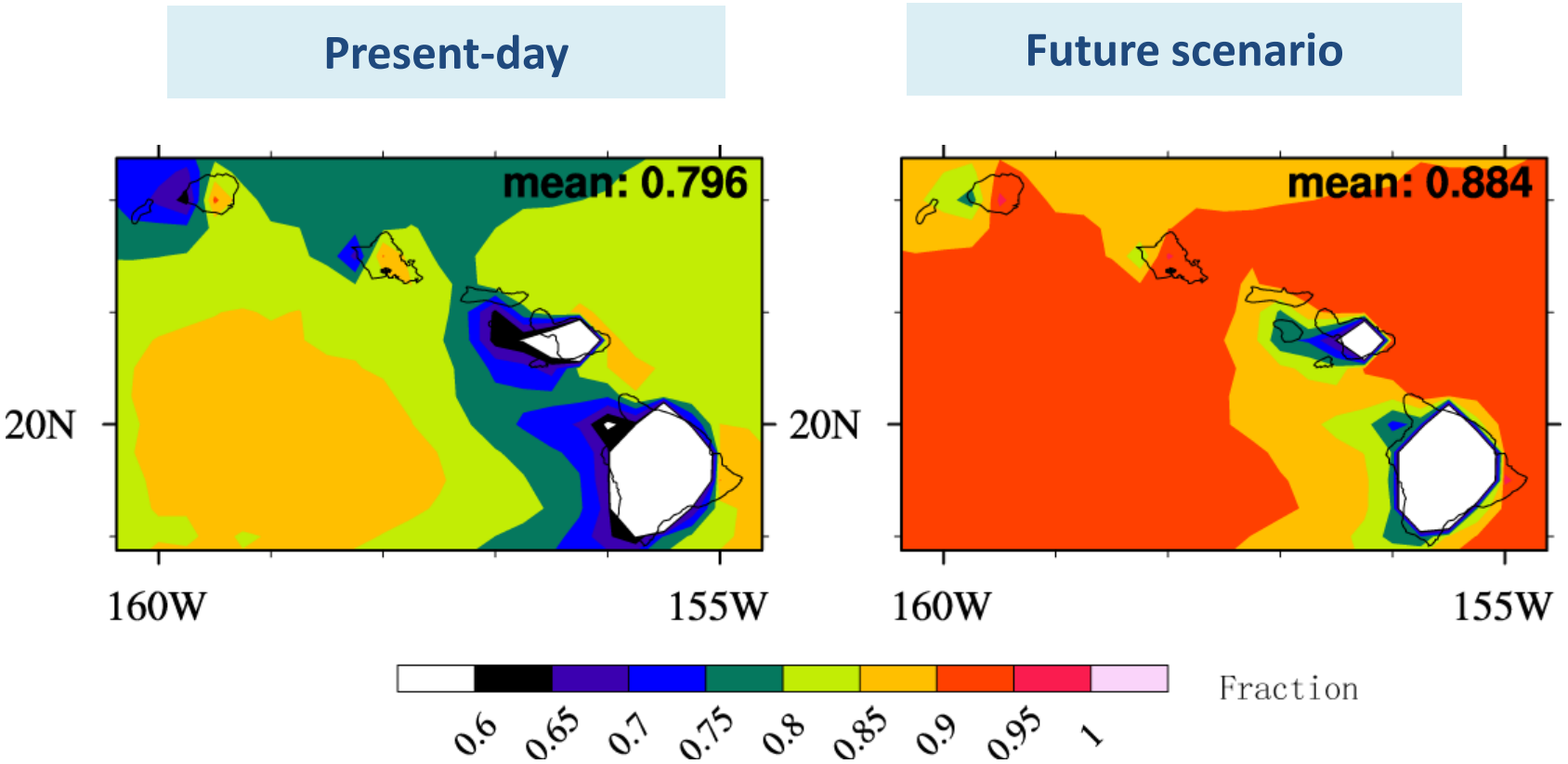
Δ rain rate



Cloud base and cloud top height (km)



Trade wind inversion frequency

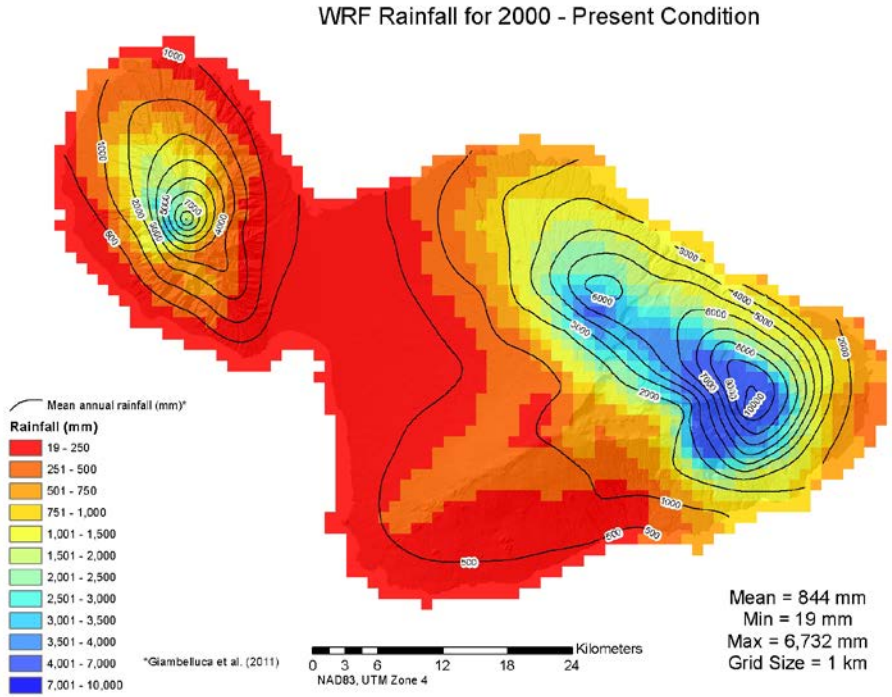


Preliminary HRCM results (2)

Model domain D3 (1 km)

1-year means (2000)

Annual Mean Rainfall



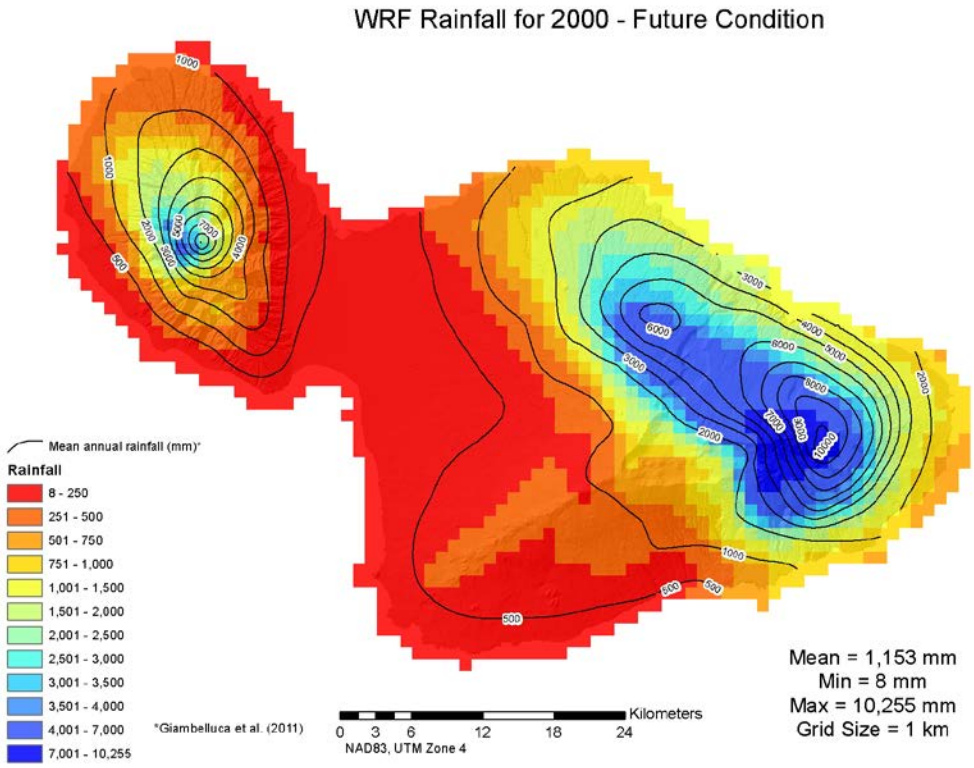
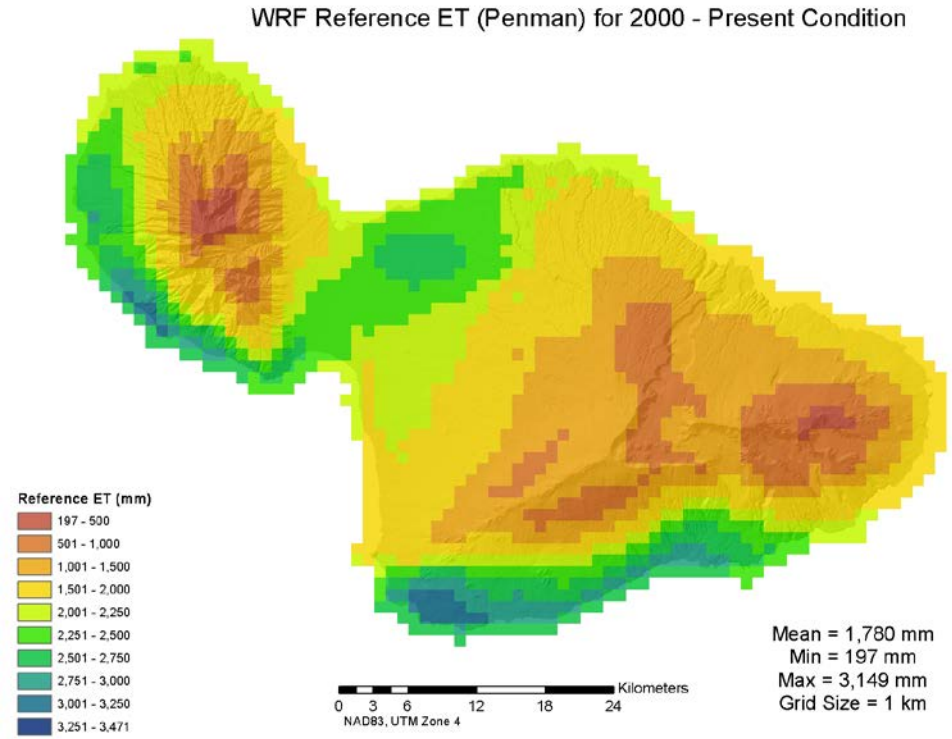


Figure by Alan Mair

Annual Mean Reference ET



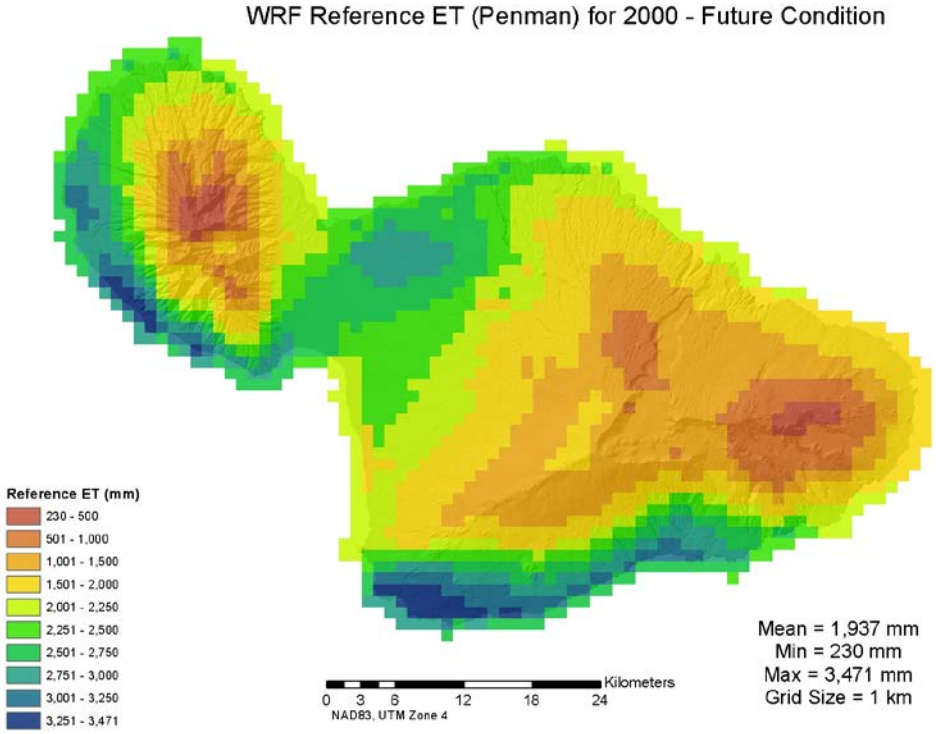
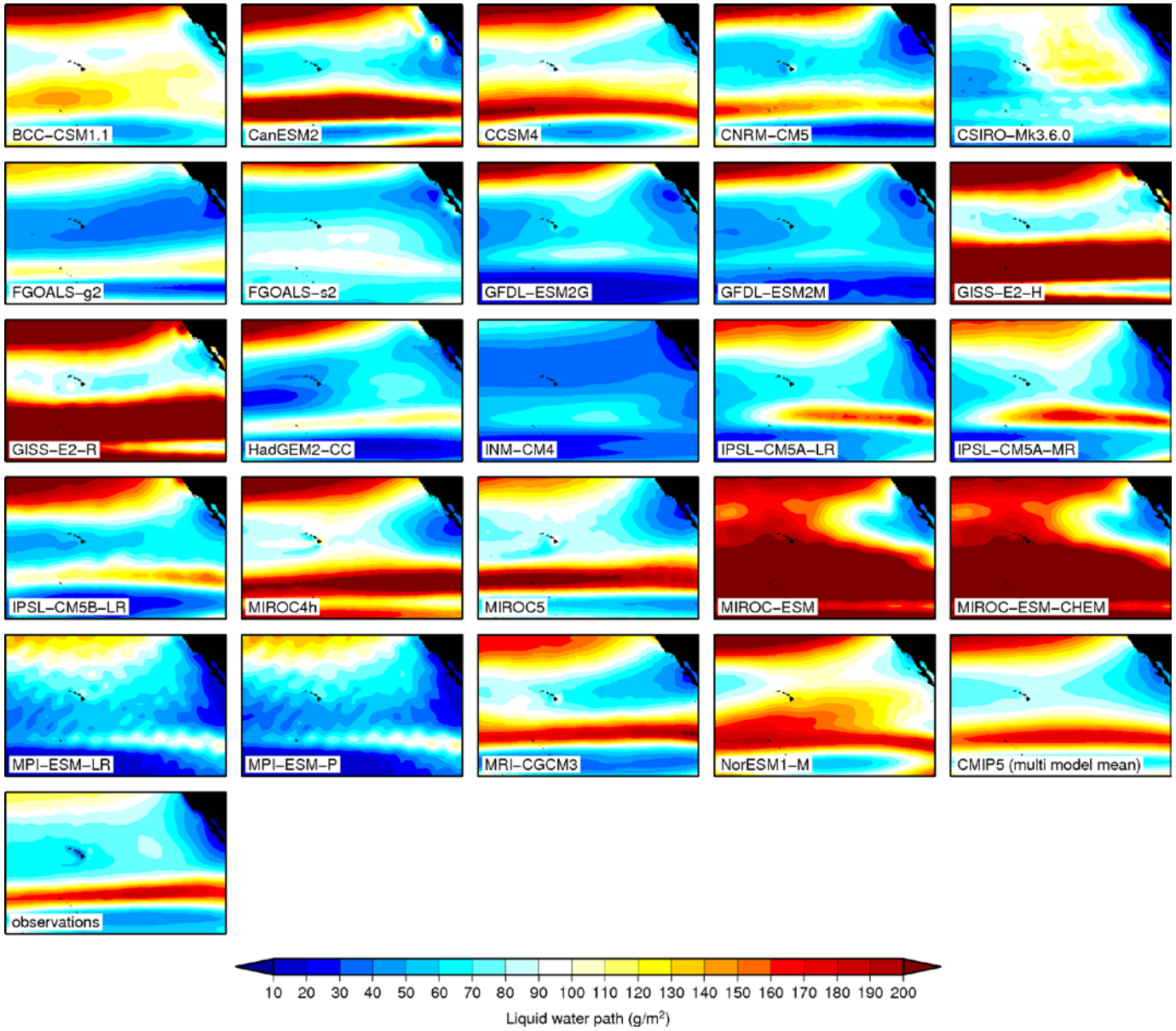


Figure by Alan Mair

20-year mean LWP (liquid water path) from CMIP5 models



Strategy and future plans

Future plans

- Finish 20-year present-day simulation at 3 km
- Continue evaluation of 1 km runs for Maui
- Investigate the uncertainty associated with underlying global warming scenarios:
  - CMIP5 RCP4.5/RCP6.0/RCP8.5
  - individual models vs. ensemble mean
  - pseudo-global-warming method vs. driving HRCM with CMIP5 output directly)
- Dynamical downscaling of CMIP5 results for the next 50 and 100 years

HRCM reference

Zhang, C., Y. Wang, A. Lauer, and K. Hamilton (2012): Configuration and Evaluation of the WRF Model for the Study of Hawaiian Regional Climate, *Mon. Wea. Rev.*, doi: 10.1175/MWR-D-11-00260.1


Thank you!