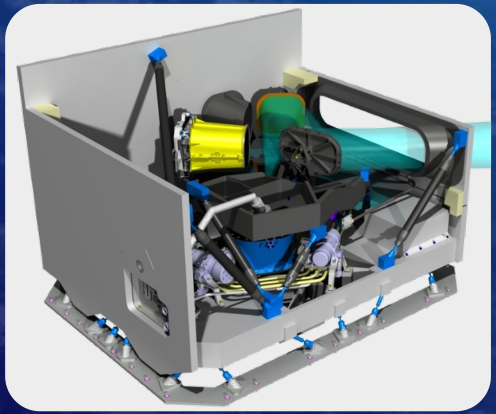
TRISHNA SURFACE TEMPERATURE AND EMISSIVITY RETRIEVALS

COMPARISON OF MULTIPLE ALGORITHMS

Emilie Delogu, Sébastien Marcq, Morgane Chapelier, Thomas Vidal, Aimé Meygret



Retrieving surface temperature and emissivity from multispectral measurements

Non-deterministic process – for any spectral band k of a given sensor in the TIR

$$L_{TOA}^{k} = \left(\epsilon^{k} L_{BB}^{k}(T_s) + \left(1 - \epsilon^{k}\right) L_{atm}^{\downarrow,k}\right)\tau^{\uparrow,k} + L_{atm}^{\uparrow,k}$$

- L_{TOA}^{k} TOA radiation reaching the satellite - measured
- $L_{BB}^{k}(T_s)$ emitted surface radiation, expressed as by the Planck's Law, depends on the surface temperature Ts – *1 unknown*
- ϵ^{k} surface emissivity – *k unknowns*
- $\tau^{\uparrow,k}$, $L_{atm}^{\uparrow,k}$ and $L_{atm}^{\downarrow,k}$ computed with an atmospheric radiative transfer code (RTTOV) using atmospheric profiles

→ derivation of the radiative transfer equation for surface temperature and emissivity is not possible without additional information, as there are more unknowns (k+1) than equations (k)

Retrieving surface temperature and emissivity from multispectral measurements

Empirical split window (SW) method
→ 2 adjacent TIR channels (in the 10–12.5 µm interval)
→ **hypothesis** : most natural surfaces have a flat emissivity spectrum in that TIR domain
→ commonly used over oceans to compute SST

→ Need calibration
→ Need a priori information on surface emissivity

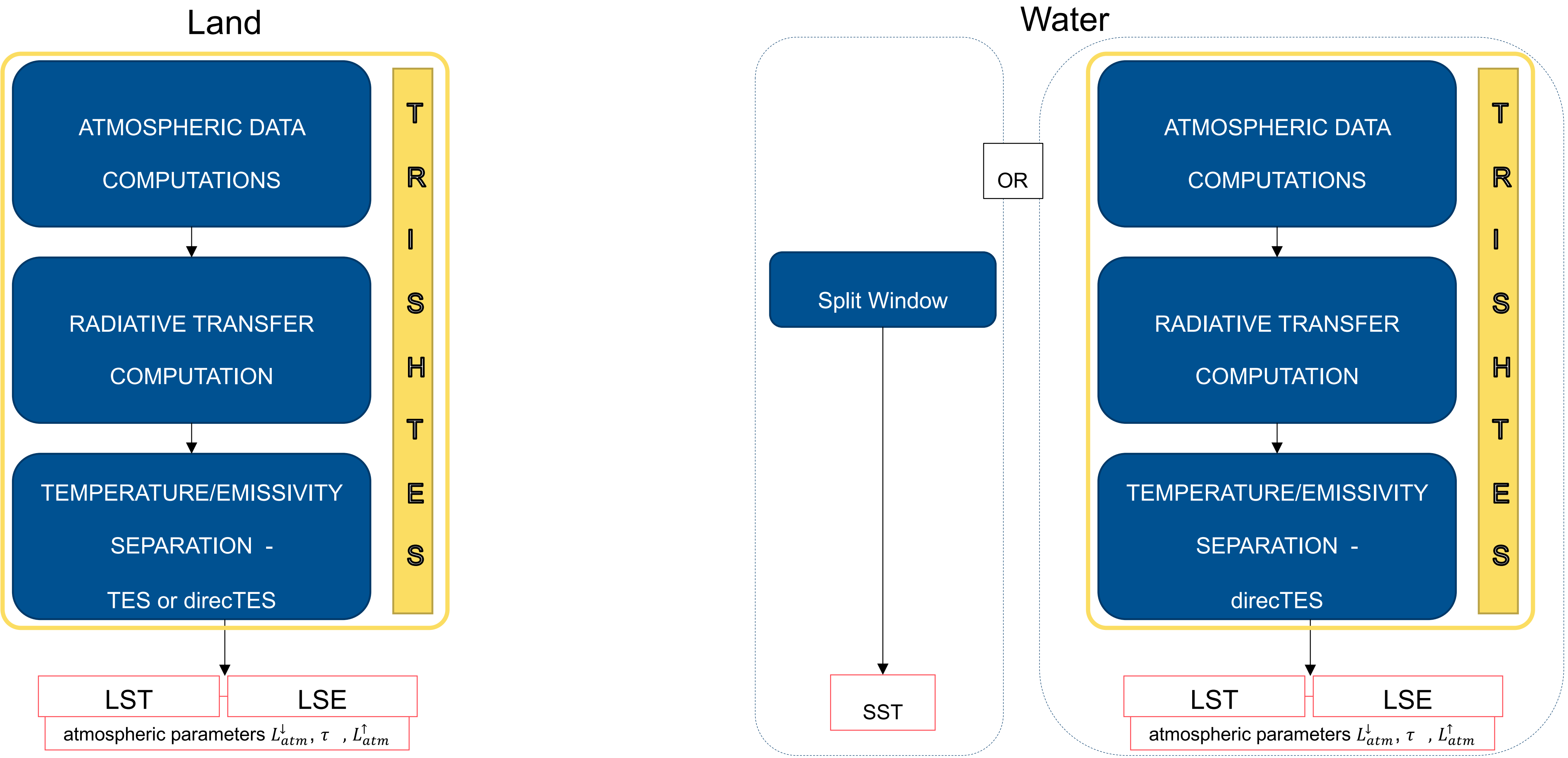
TES algorithm → initially developed for ASTER, empirical relationship between spectral contrast and minimum emissivity
→ **hypothesis** : over 3 channels in the TIR domain, at least one value close to unity

→ Need atmospheric correction
→ not adapted for surfaces with low spectral contrast emissivity and under hot and wet atmospheric conditions

DirecTES algorithm → developed at CNES
→ spectral database of emissivity
→ **principle** : calculate the LST for each pixel and each material of the spectral library. If temperatures are consistent for a given material in the N spectral bands→ material and LST are considered valid
→ Possibility to add consistent surface reflectance in the VSWIR criterion

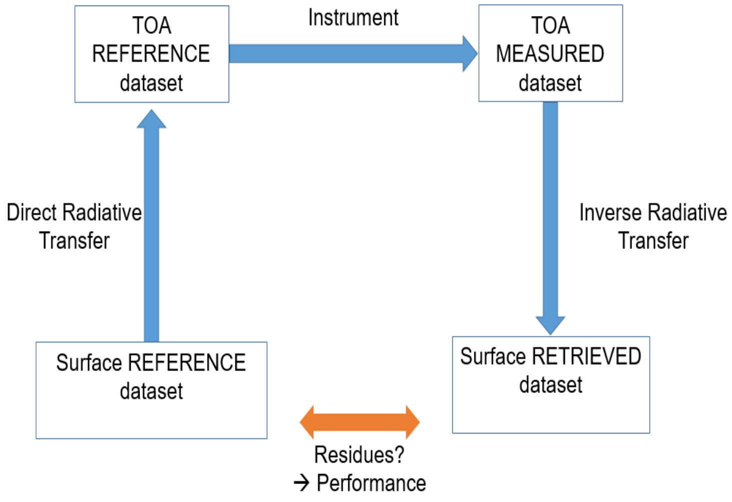
→ Need atmospheric correction
→ Strongly depends on the spectral library used

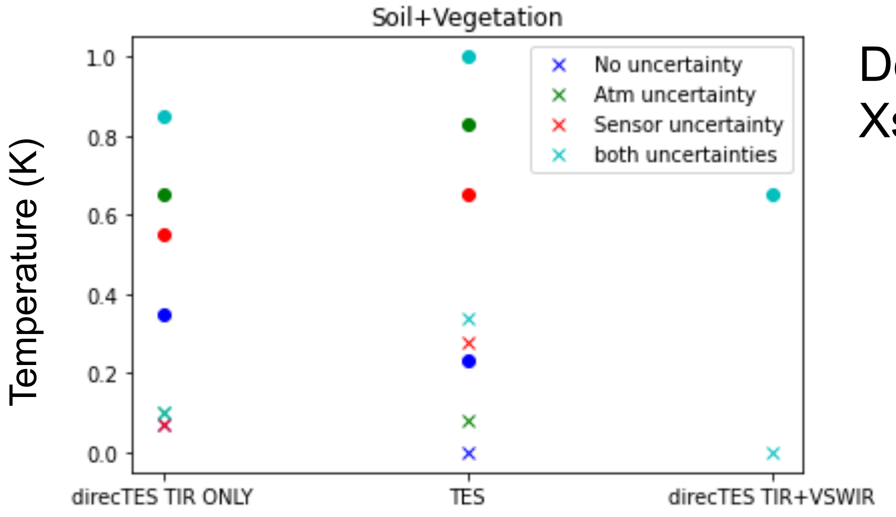
Retrieving surface temperature and emissivity for TRISHNA – different algorithms under study



Retrieving surface temperature and emissivity for TRISHNA – Comparison of TES and direcTES for LST retrievals

End to End simulations





Dots : RMSE
Xs : bias

Surface reference data = 3 datasets

- Soil+vegetation
- Water (+ice, snow)
- « urban » (manmade&soil)

With both sources of uncertainty:

- 0.1K bias for direcTES (TIR) vs 0.3K for TES
- 0.85-1K RMSE for direcTES (TIR) and TES
- no bias and 0.65K RMSE for direcTES (TIR+VSWIR)

Retrieving surface temperature and emissivity for TRISHNA – Comparison of TES and direcTES for LST retrievals

ECOSTRESS data

5 sites with evaluated uncertainties (Hulley et al., 2022)

Russel Ranch
Gobabeb
Lake Tahoe
Texas Grassland
Redwood Forest

ECOSTRESS L1C + Atmospheric Profiles (ECMWF)

↓

TRISHTES (TES or direcTES) + VNIR-SWIR information (Sentinel2 colocated products)

↓

« TRISHNA-LIKE » L2 ⟷ (Comparison) ⟷ ECOSTRESS L2

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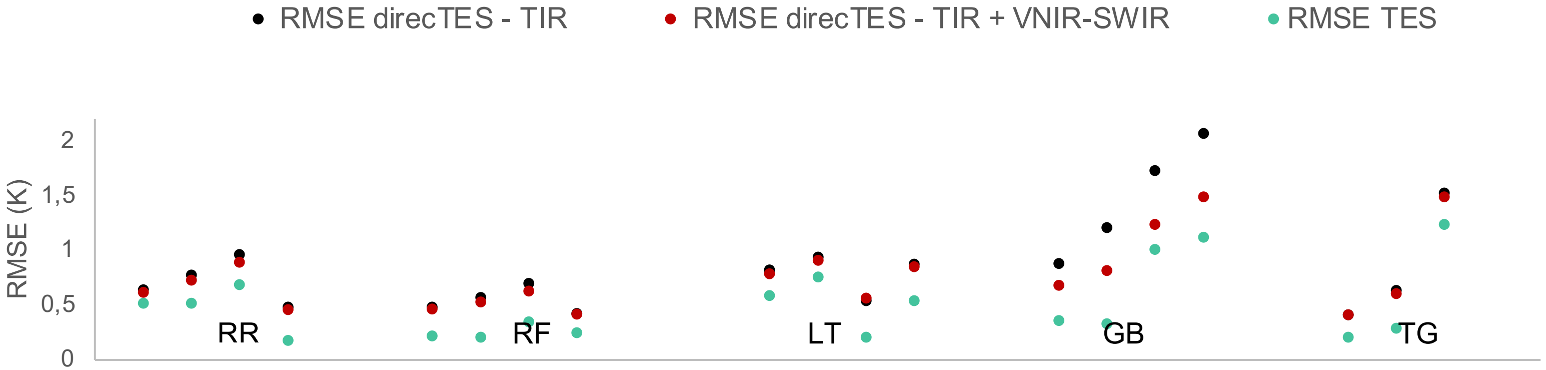
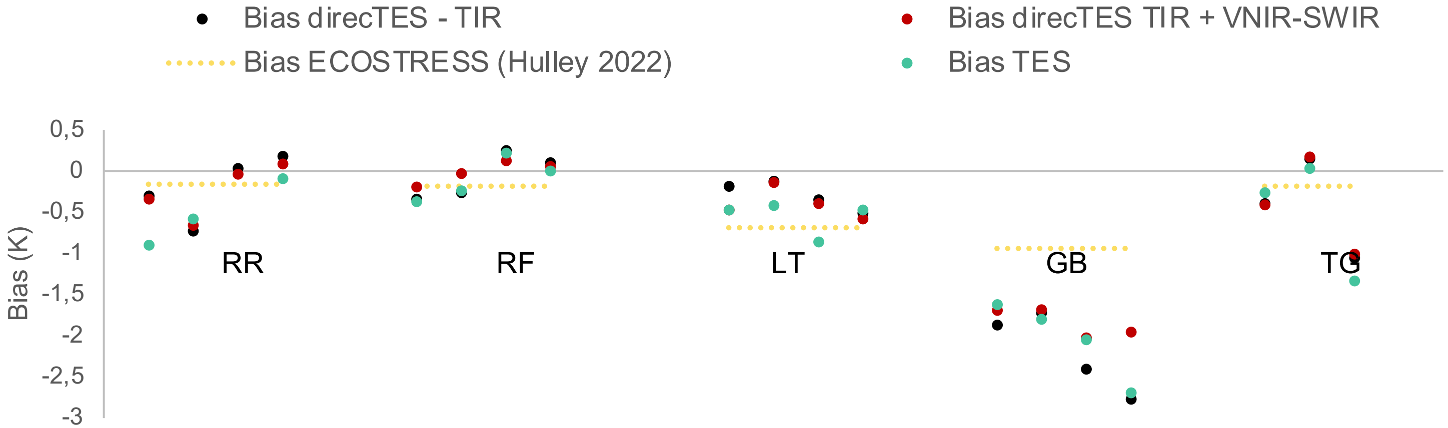
ECOSTRESS data



RMSE and bias between ECOSTRESS and TES, direcTES TIR and direcTES TIR + VNIR-SWIR LST on the whole images containing the 5 selected sites

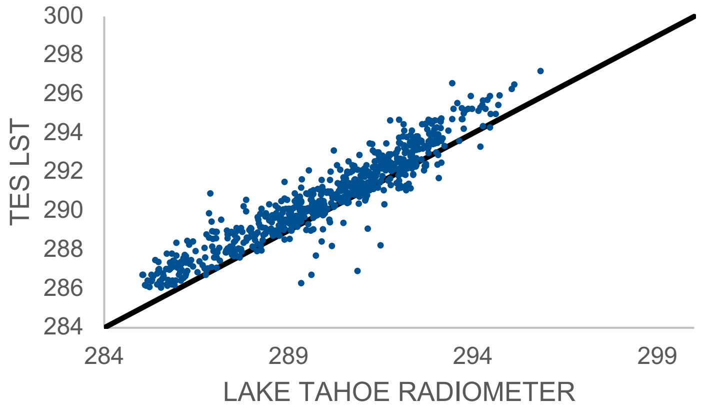


ECOSTRESS L2 = RTTOV+TES

- RMSE
  direcTES (0.5 – 1.5K) > TES (0.2 – 1.2K)
- Cold bias
  TES > direcTES
- availability of only 3 ECOSTRESS bands is not ideal for direcTES usage

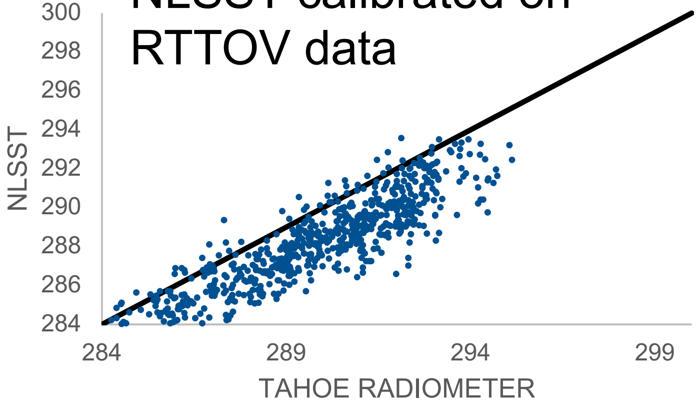
Retrieving surface temperature and emissivity for TRISHNA – Comparison of TES, direcTES and SW NLSST for SST retrievals

In situ data : TAHOE JPL RADIOMETER and ECOSTRESS L1 colelction 2 data



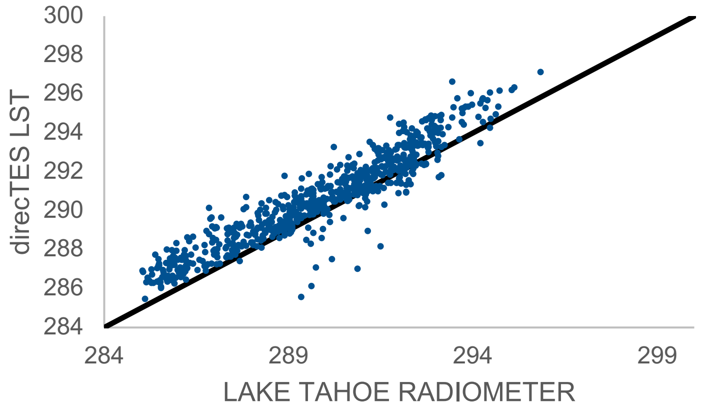
Bias = 0.69 K
RMSE = 0.88 K

NLSST calibrated on RTTOV data



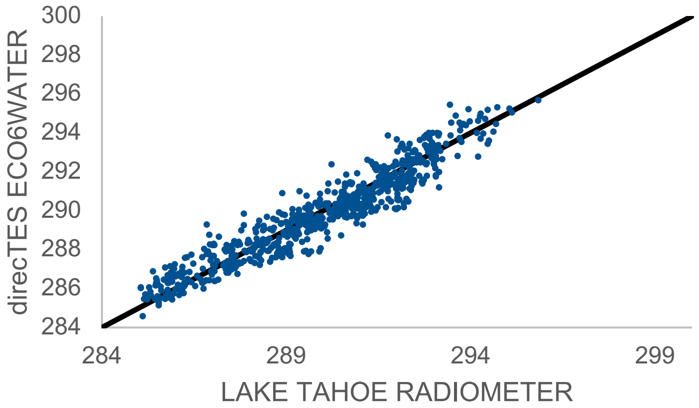
Bias = -1.62 K
RMSE = 1.85 K

SST retrieval performance **using the same calibration as for LST**



Bias = 0.77 K
RMSE = 0.90 K

SST retrieval performance **using a water emissivity database**



Bias = -0.02 K
RMSE = 0.65 K

Conclusion

TES and direcTES performances for LST retrievals are similar (slightly better RMSEs for TES) → evaluated over ECOSTRESS retrievals

- → Need to be careful on conclusions : ECOSTRESS LST is produced from RTTOV + TES algorithms
- → No comparison to actual in situ data yet
- → direcTES can be improved : multi temporal approach to avoid ambiguity on materials, better definition of the spectral library…

direcTES performances for SST retrievals are promising
→ Further Comparisons with SW NLSST are needed before making a choice for TRISHNA

direcTES for SST :
→ Process an atmospheric correction
→ Under study : All the error comes from instrument and atmospheric uncertainties : possibility to perform the inversion over a noisy atmospheric library in place of the spectral emissivity library assuming water emissivity is known

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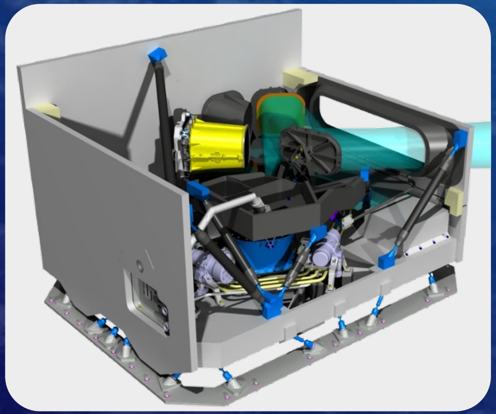

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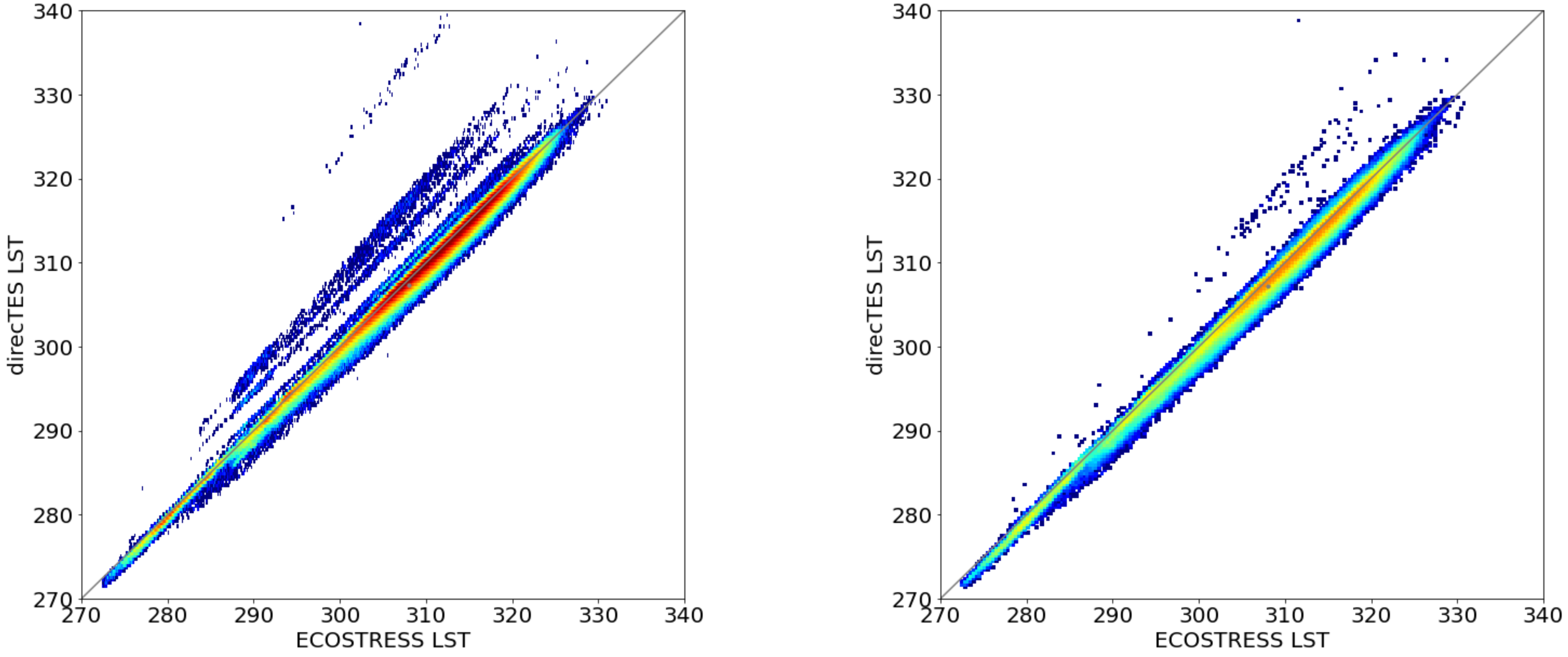
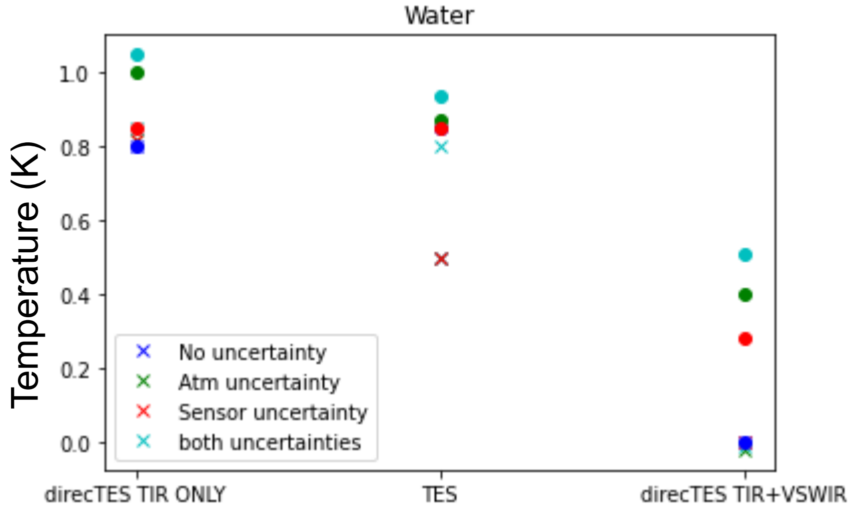
ECOSTRESS data



Comparison of ECOSTRESS and DirecTES TIR and DirecTES TIR + VNIR-SWIR LST on whole image over Russell Ranch (9 June 2019).

Retrieving surface temperature and emissivity for TRISHNA – Comparison of TES and direcTES for SST retrievals

End to End simulations



Dots : RMSE
Xs : bias

Significant bias for direcTES (TIR only) and TES which makes most of the RMSE
TES RMSE is slightly better

→ Bias reduced for direcTES TIR+VSWIR and RMSE comes from uncertainties only

TES : the land calibration is not at all adapted → there may be room for improvement.