High Resolution Gridded Datasets of Hydroclimate Indices for Ireland

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MET éireann

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An Roinn Post, Fiontar agus Nuálaíochta
Department of Jobs, Enterprise and Innovation

sfi
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DEPARTMENT OF EDUCATION AND SKILLS

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Overview and Goals

- Produce long-term gridded datasets (1981-present) for priority climatological variables
- Evaluate relative skill of derived products and assign uncertainty estimates by comparing with observational data
- Collaborate with the Met Éireann Agricultural & Environmental Unit to facilitate updating the "Agroclimatic Atlas of Ireland"
- Communicate and disseminate results to key stakeholders, policy makers and academia

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Dataset Overview

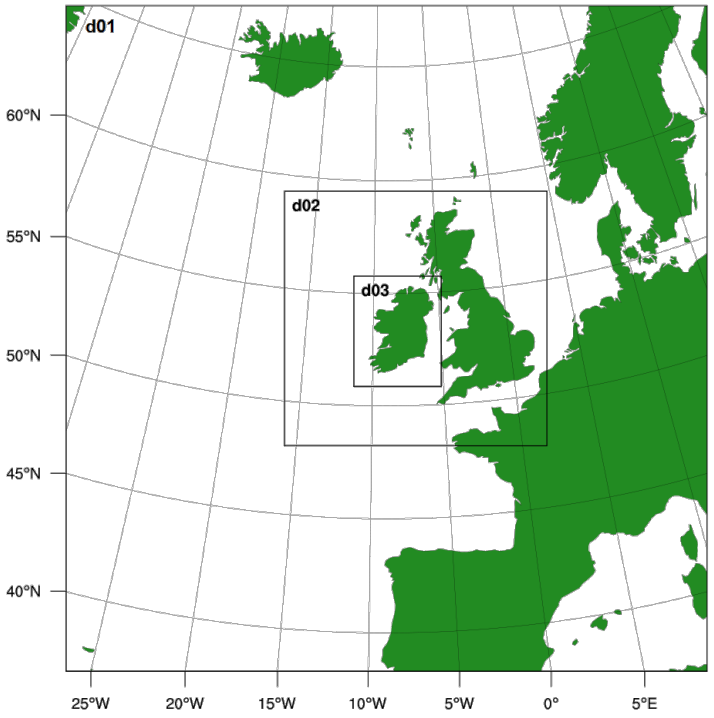
ICHEC: WRF v.3.7.1, COSMO-CLM5

Outer domains: 18km, 6km

Inner domains:

- WRF = 2 km
- COSMO-CLM = 1.5 km

WRF domains



Met Éireann Reanalysis Dataset (MÉRA)

MERA simulation downscaled directly from global to 2.5km using HARMONIE NWP

Better performance and skill expected due to data assimilation

MÉRA domain

Formulas

FAO Penman-Monteith Equation for Reference Evapotranspiration (ET_0) (Allen et al 1998)

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T_{mean} + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)} \times (K_{c=1})$$

Crop evapotranspiration

$$ET_{p/c} = K_c \cdot ET_0$$

ET_0 = reference evapotranspiration (mm/day)
R_n = net radiation (MJ m^{-2} day^{-1})
G = soil heat flux (MJ m^{-2} day^{-1})
e_s = saturation vapour pressure
e_a = actual vapour pressure
T_{mean} = average temperature at 2 m (°C)
u_2 = 2 m windspeed
Δ = slope of vapour pressure curve (kPa $°C^{-1}$)
γ = psychometric constant (kPa $°C^{-1}$)
C_n = numerator constant (grass = 900)
C_d = denominator constant (grass = 0.34)
$ET_{p/c}$ = potential/crop evapotranspiration
K_c = crop coefficient

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Formulas

Met Éireann Hybrid Soil Moisture Deficit Model (Schulte et al 2005)

$$SMD_t = SMD_{t-1} - P + ET_a + D$$

When $SMD \leq SMD_{c/min}$ → $ET_a = ET_o$

When $SMD > SMD_{c/min}$ → $ET_a = ET_o \cdot \frac{SMD_{max} - SMD_{t-1}}{SMD_{max} - SMD_c}$

Drainage Classes	SMD_{max}	SMD_{min}	D_{max}
Excessive	50mm	0mm	∞
Well	110mm	0mm	∞
Moderately	110mm	0mm	10mm
Imperfectly	110mm	0mm	3mm
Poorly	110mm	- 10mm	0.5mm

Hybrid Soil Moisture Deficit Model (Schulte et al 2015)

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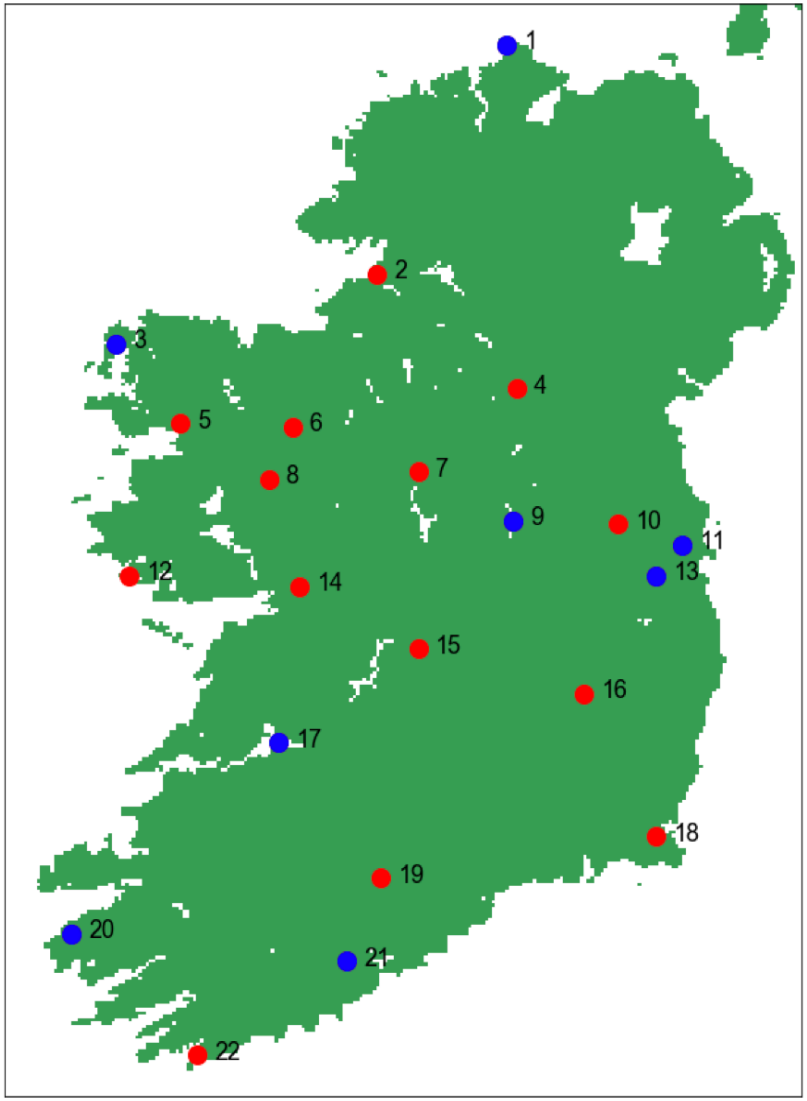
Bias Corrections



1 - Malin Head
2 - Finner
3 - Belmullet
4 - Ballyhaise
5 - Newport
6 - Knock Airport
7 - Mt Dillon
8 - Claremorris
9 - Mullingar
10 - Dunsany
11 - Dublin Airport
12 - Mace Head
13 - Casement
14 - Athenry
15 - Gurteen Agri-College
16 - Oak Park
17 - Shannon Airport
18 - Johnstown
19 - Moore Park
20 - Valentia Observatory
21 - Cork Airport
22 - Sherkin Island

- Derived using least squared estimator method
- Done monthly to account for changing ET_0 during the year
- Grid of Ireland derived from location of 22 synoptic stations 2006-2017
- Derived from distance weighted averages
- Maps of $\hat{a}$ and $\hat{b}$ compiled and applied to ET_0

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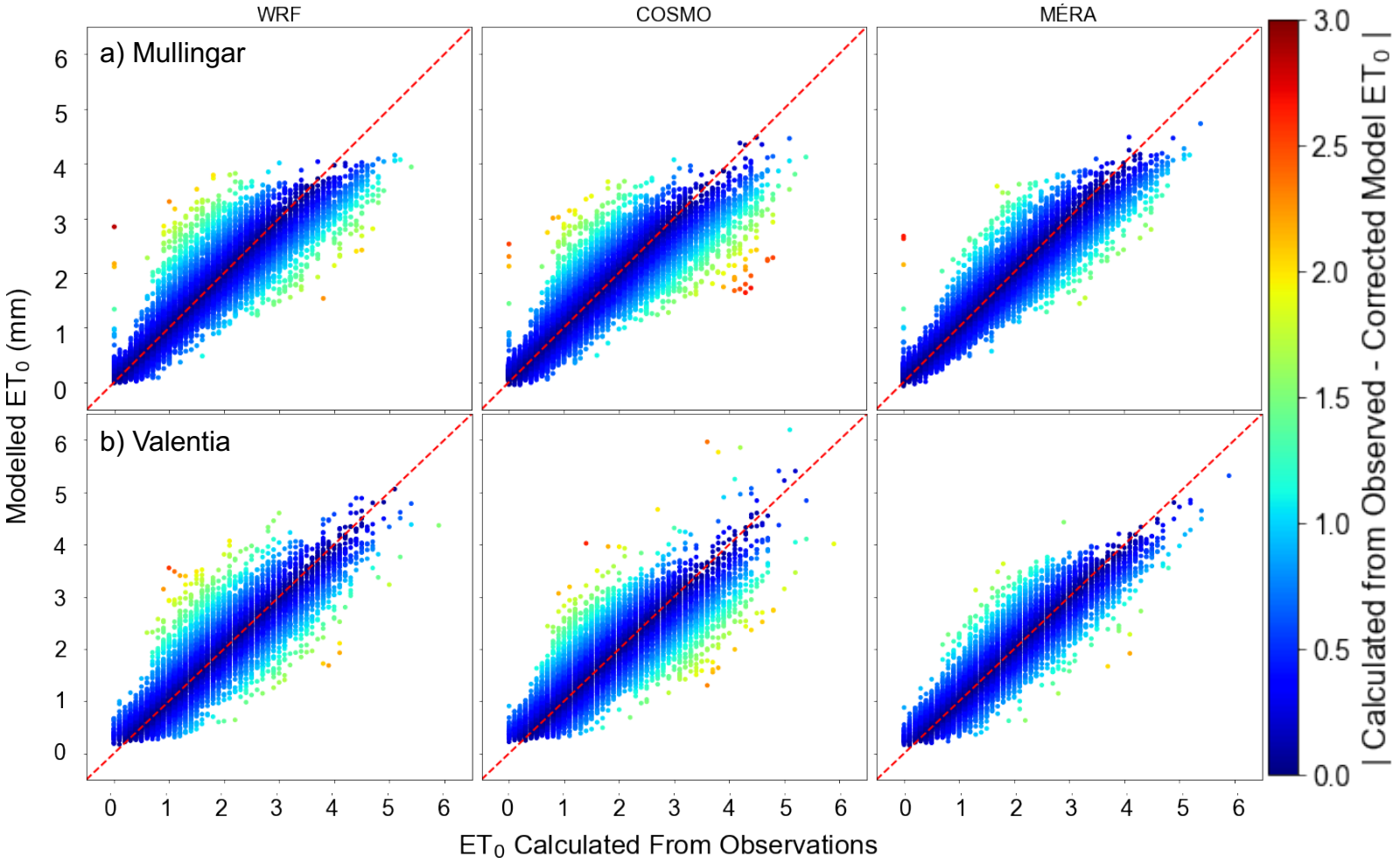
Reference Evapotranspiration (ET_0) Daily Scatter Plots



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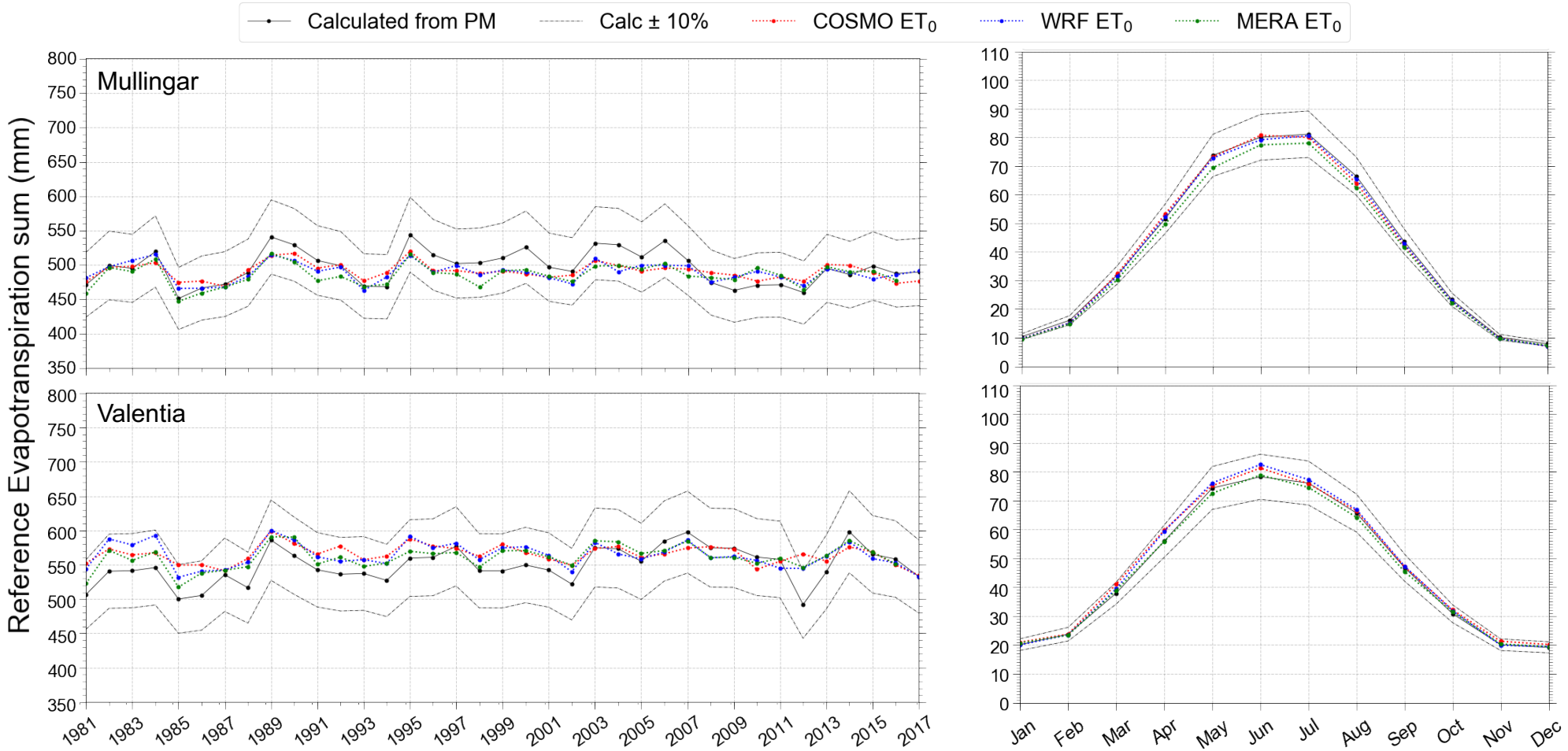
ET_0 Yearly sums and Monthly average sums



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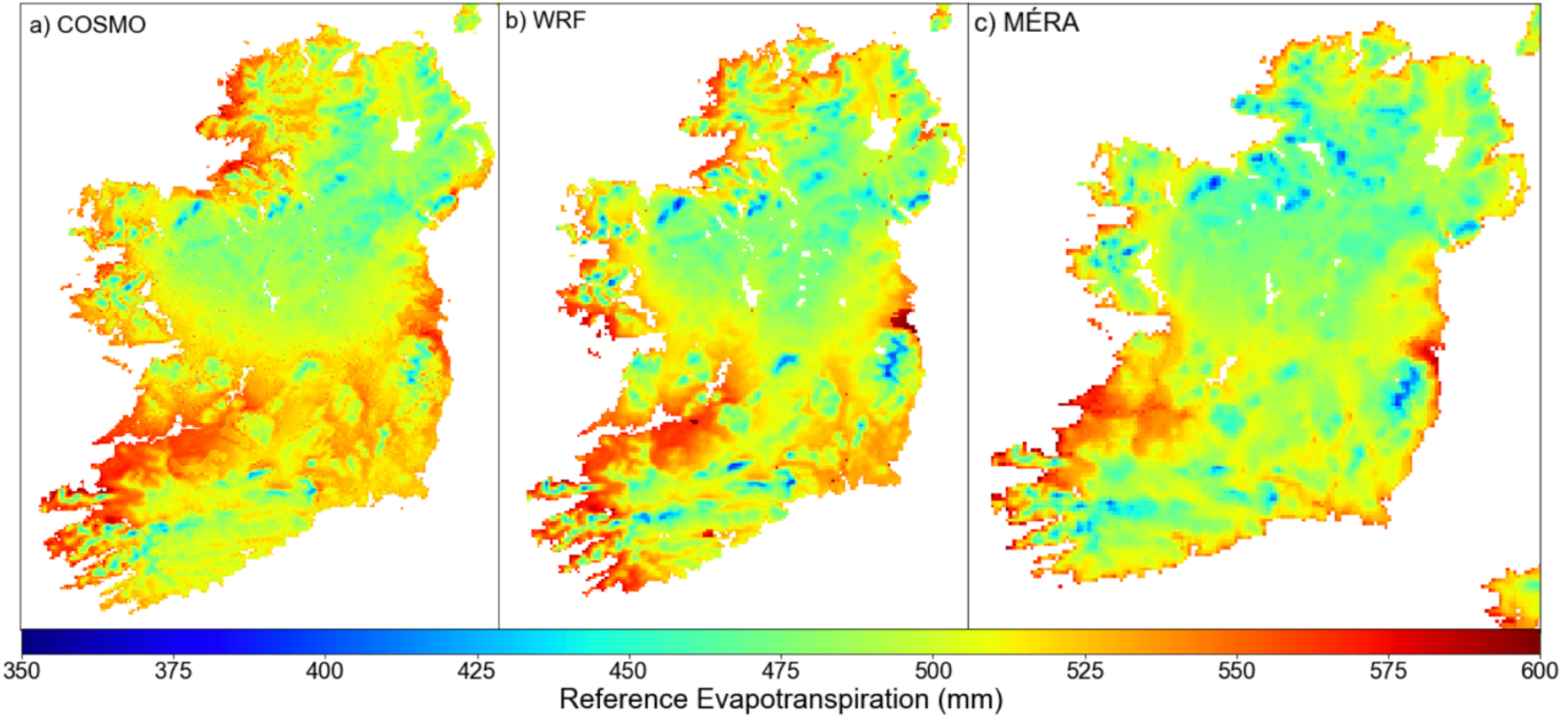
Average Annual Reference Evapotranspiration (ET_0) sum for a) COSMO, b) WRF, c) MÉRA



	RMSE			ST.DEV			Corr.Coeff		
	COSMO	WRF	MÉRA	COSMO	WRF	MÉRA	COSMO	WRF	MÉRA
DAILY	0.442	0.402	0.337	0.882	0.937	0.924	0.892	0.913	0.939
YEARLY	24.164	21.293	20.402	12.301	14.035	14.813	0.561	0.678	0.755

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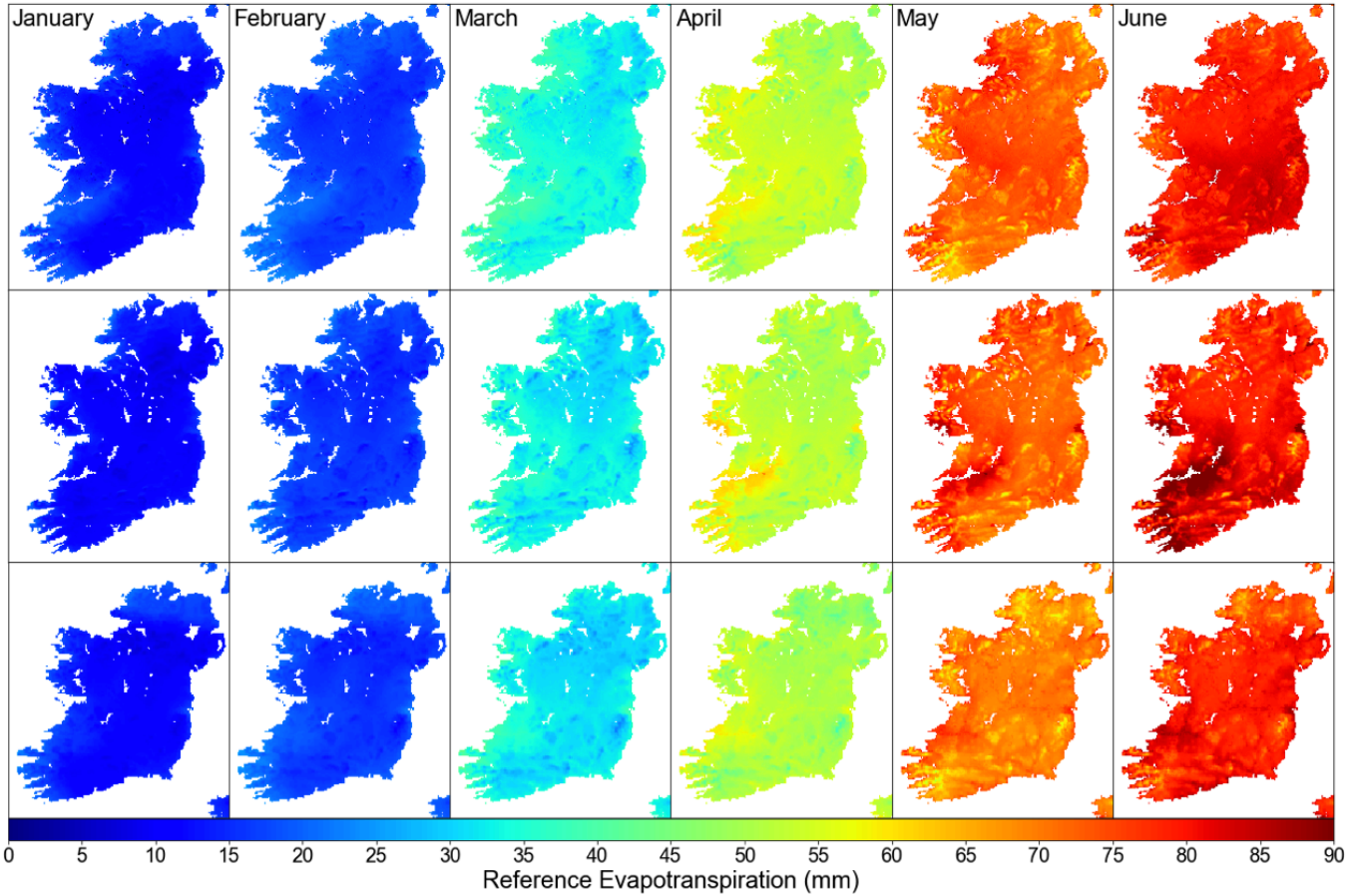
Reference Evapotranspiration (ET_0) –Monthly Average sums 1981-2016/17

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jan	Feb	Mar	Apr	May	Jun	DAILY	Jan	Feb	Mar	Apr	May	Jun
COSMO		2.644	2.724	2.8	4.272	5.733	5.956		0.22	0.232	0.324	0.465	0.605	0.7
WRF		2.895	2.797	2.446	3.795	4.82	5.505		0.217	0.218	0.277	0.402	0.559	0.642
MÉRA		2.458	2.397	2.437	2.617	3.929	4.016		0.197	0.202	0.265	0.338	0.433	0.499

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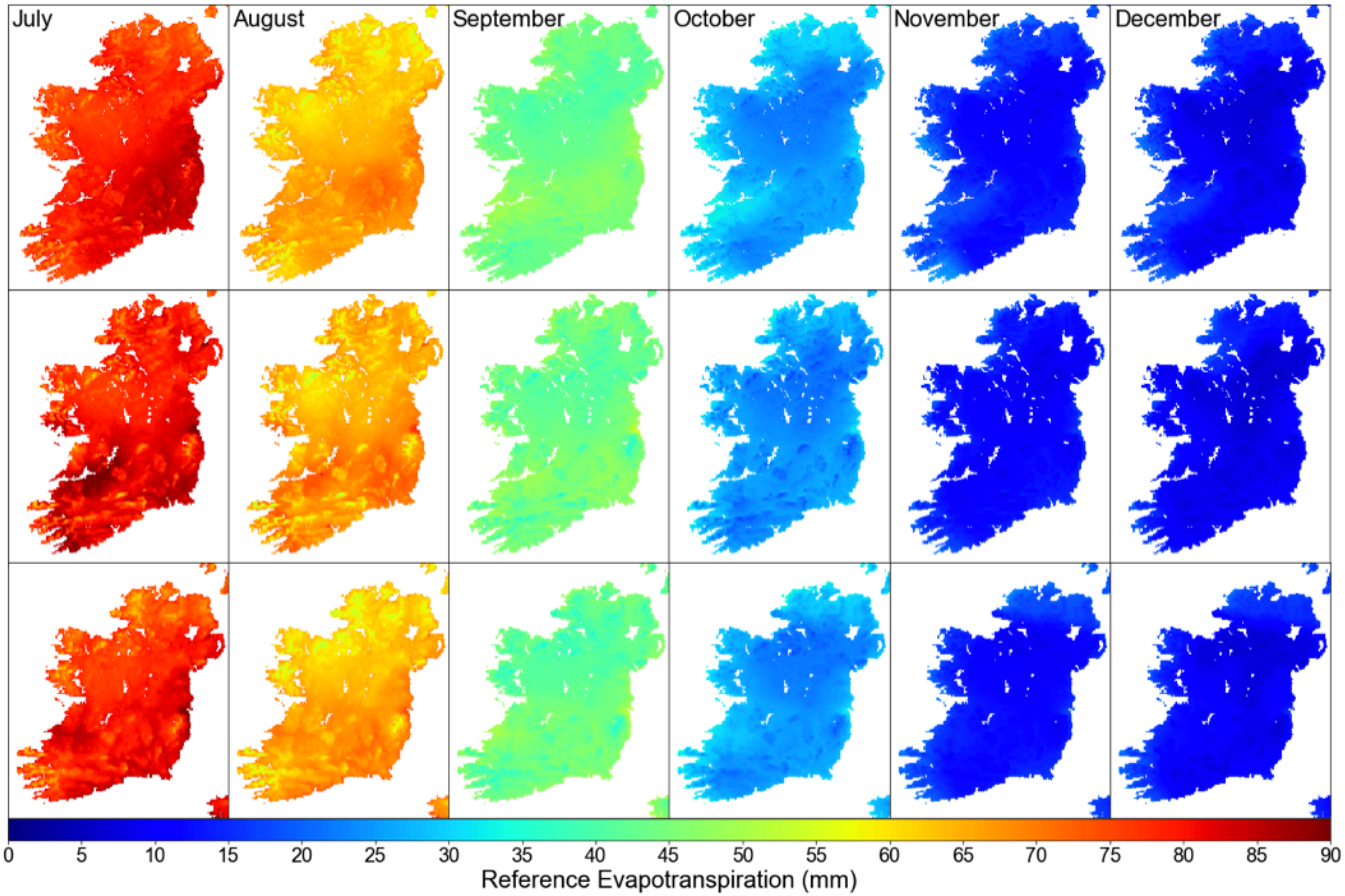
Reference Evapotranspiration (ET_0) Monthly Average sums 1981-2016/17

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jul	Aug	Sep	Oct	Nov	Dec	DAILY	Jul	Aug	Sep	Oct	Nov	Dec
COSMO		6.363	5.073	3.334	2.353	2.398	2.73		0.65	0.532	0.405	0.264	0.217	0.224
WRF		5.437	4.005	2.649	2.324	2.78	3.048		0.603	0.484	0.337	0.227	0.215	0.226
MÉRA		4.232	3.701	2.812	2.119	2.311	2.625		0.489	0.419	0.318	0.221	0.197	0.199

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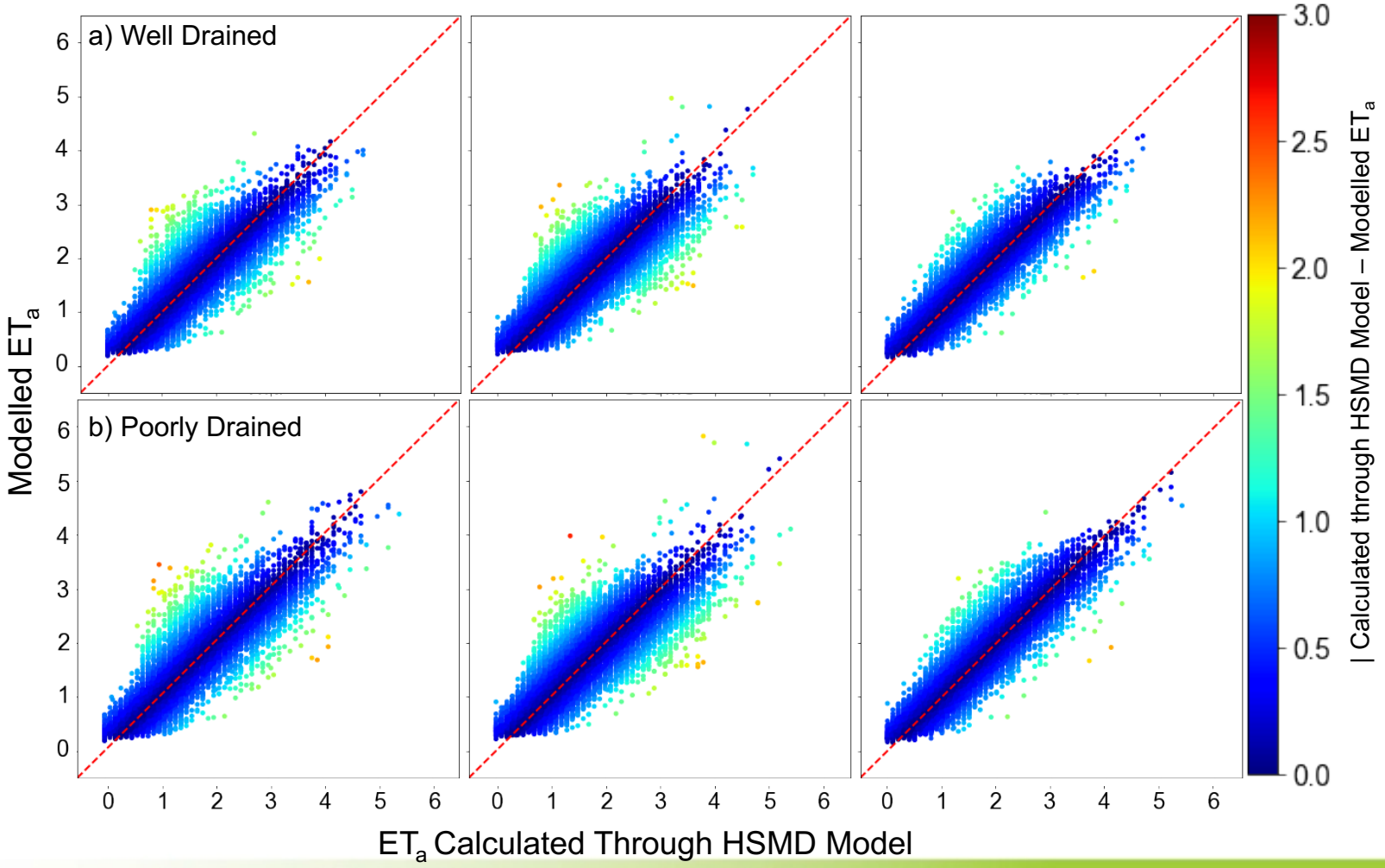
Actual Evapotranspiration (ET_a) Daily Scatter Plots at Valentia



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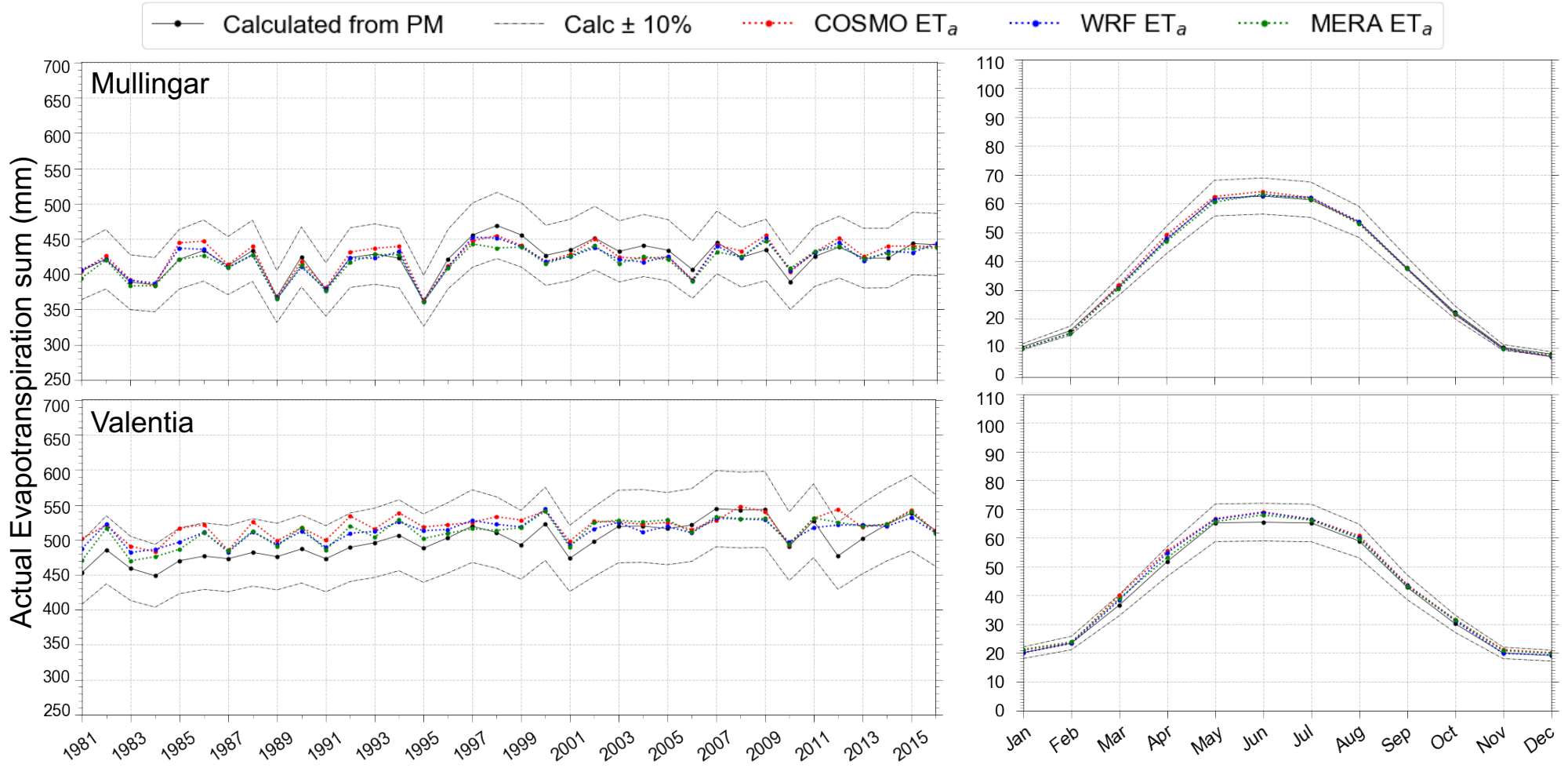
ET_a Yearly sums and Monthly average sums (Well Drained)



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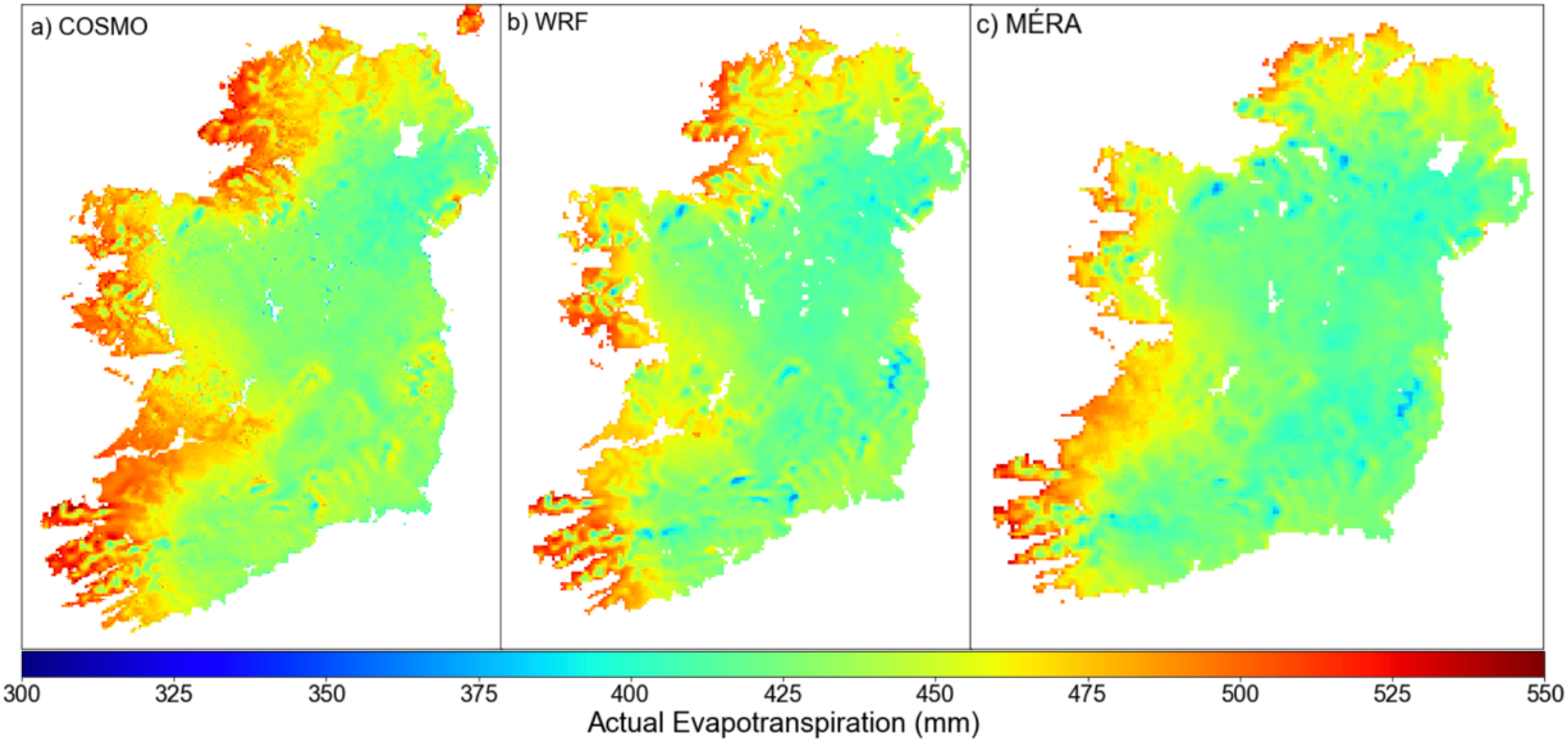
Average Annual Actual Evapotranspiration (ET_a) sum (Well Drained Soils) for a) COSMO, b) WRF, c) MÉRA



	RMSE			ST.DEV			Corr.Coeff		
	COSMO	WRF	MÉRA	COSMO	WRF	MÉRA	COSMO	WRF	MÉRA
DAILY	0.378	0.347	0.288	0.713	0.740	0.735	0.874	0.896	0.927
YEARLY	18.024	16.148	15.597	22.759	21.624	20.947	0.745	0.785	0.805

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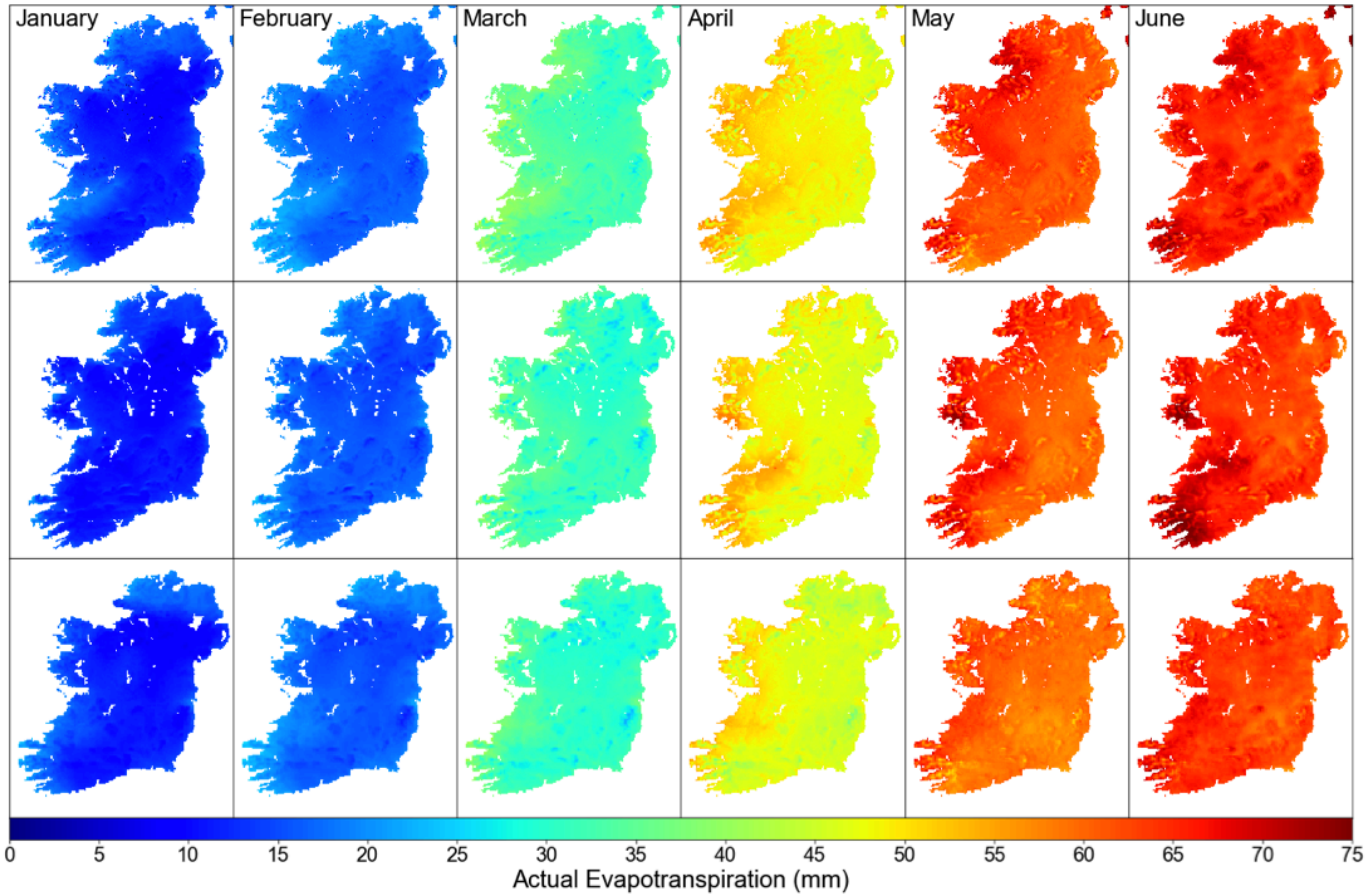
Actual Evapotranspiration (ET_a) – Well Drained Monthly Average sums 1981-2016

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jan	Feb	Mar	Apr	May	Jun	DAILY	Jan	Feb	Mar	Apr	May	Jun
COSMO		2.666	2.617	2.644	3.672	4.116	4.541		0.217	0.227	0.306	0.426	0.514	0.567
WRF		2.88	2.677	2.255	3.149	3.515	4.046		0.215	0.213	0.266	0.367	0.478	0.523
MÉRA		2.453	2.281	2.291	2.145	2.788	3.094		0.195	0.198	0.255	0.307	0.368	0.402

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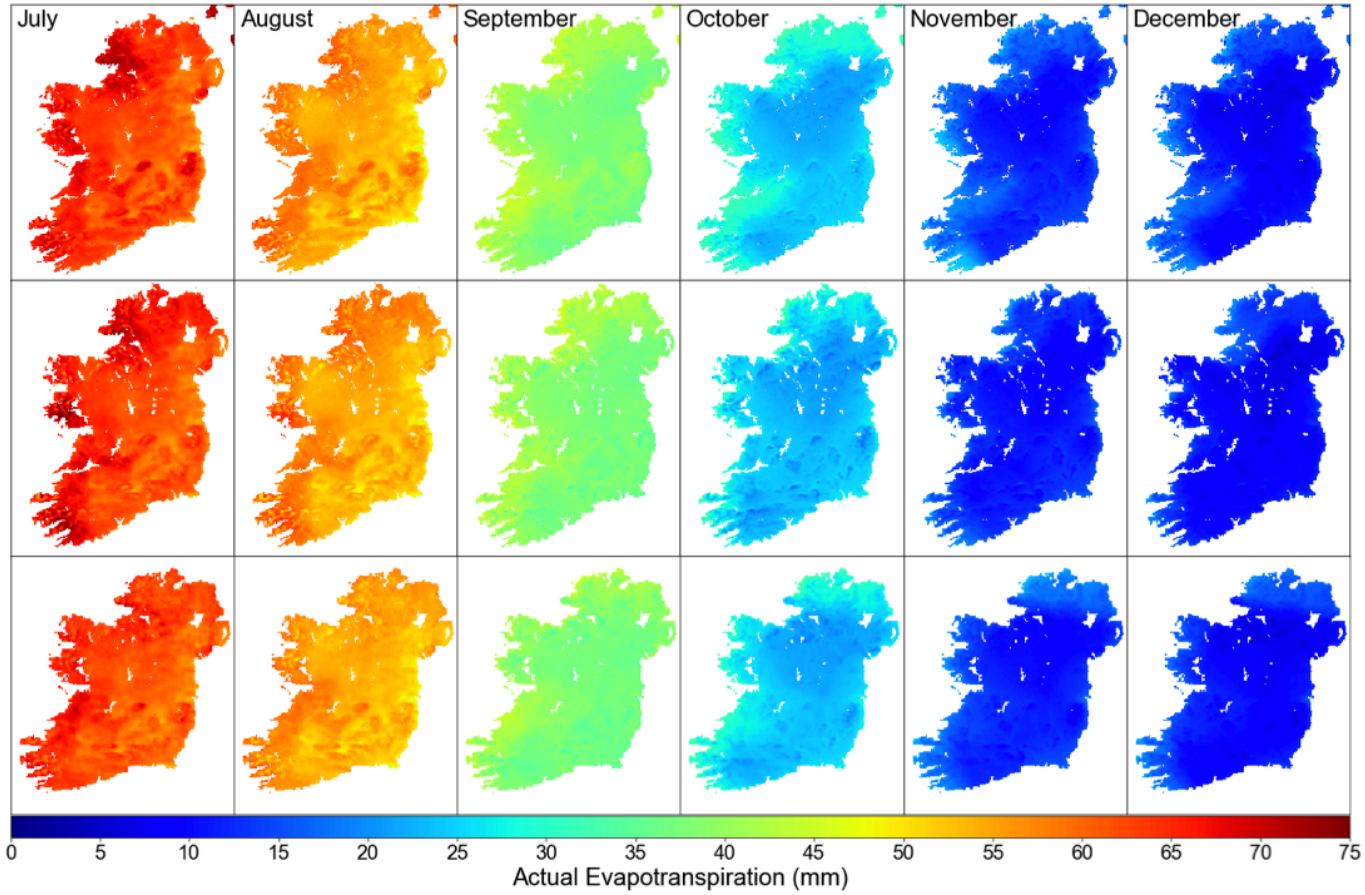
Actual Evapotranspiration (ET_a) – Well Drained Monthly Average sums 1981-2016

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jul	Aug	Sep	Oct	Nov	Dec	DAILY	Jul	Aug	Sep	Oct	Nov	Dec
COSMO		4.058	3.700	2.53	2.13	2.354	2.735		0.510	0.446	0.353	0.249	0.212	0.224
WRF		3.741	3.176	2.142	2.085	2.677	3.066		0.479	0.410	0.299	0.216	0.210	0.226
MÉRA		2.950	2.854	2.251	1.914	2.263	2.579		0.386	0.350	0.277	0.210	0.195	0.197

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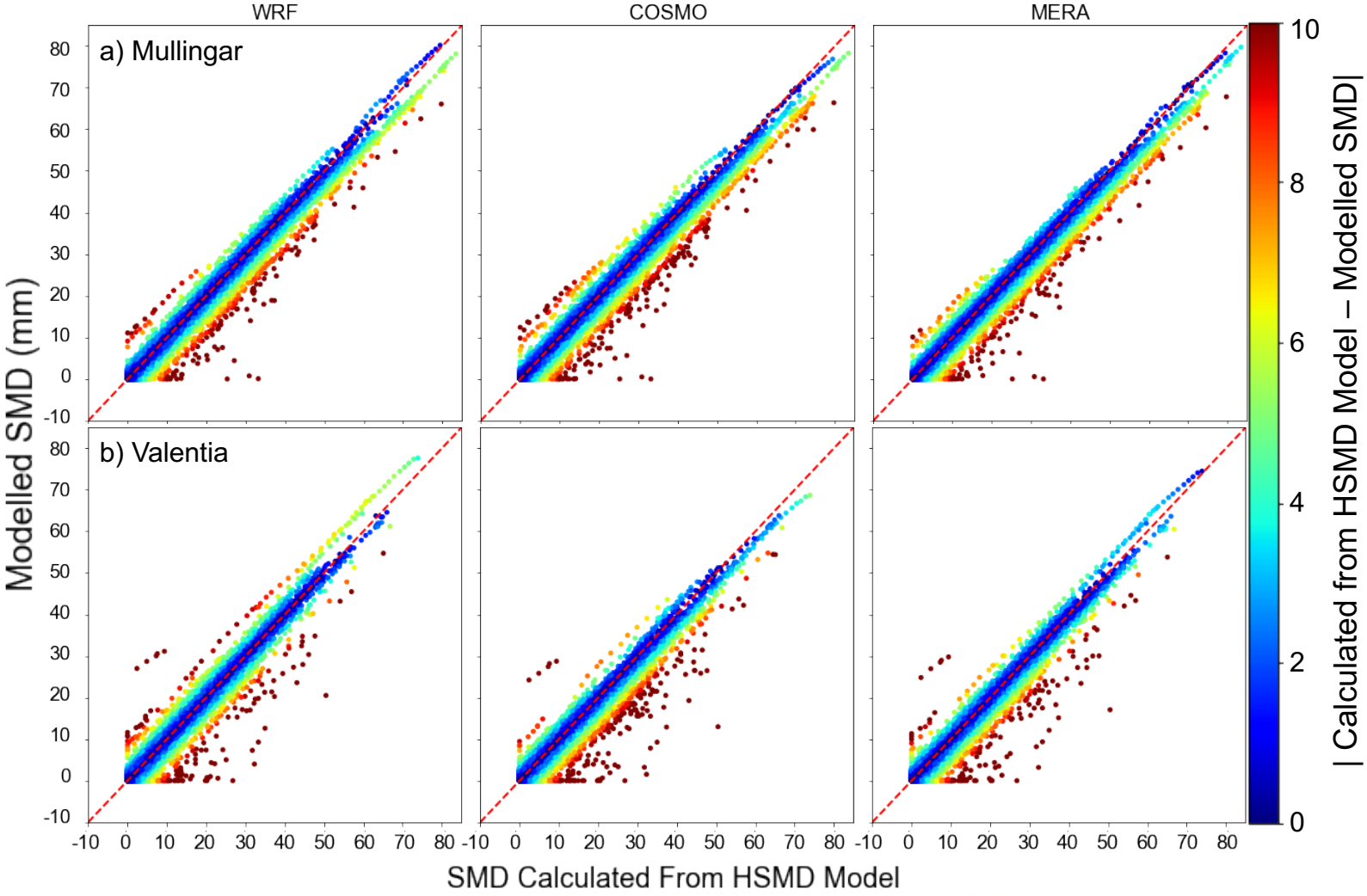
Soil Moisture Deficits (SMD) Daily Scatter Plots (Well Drained)



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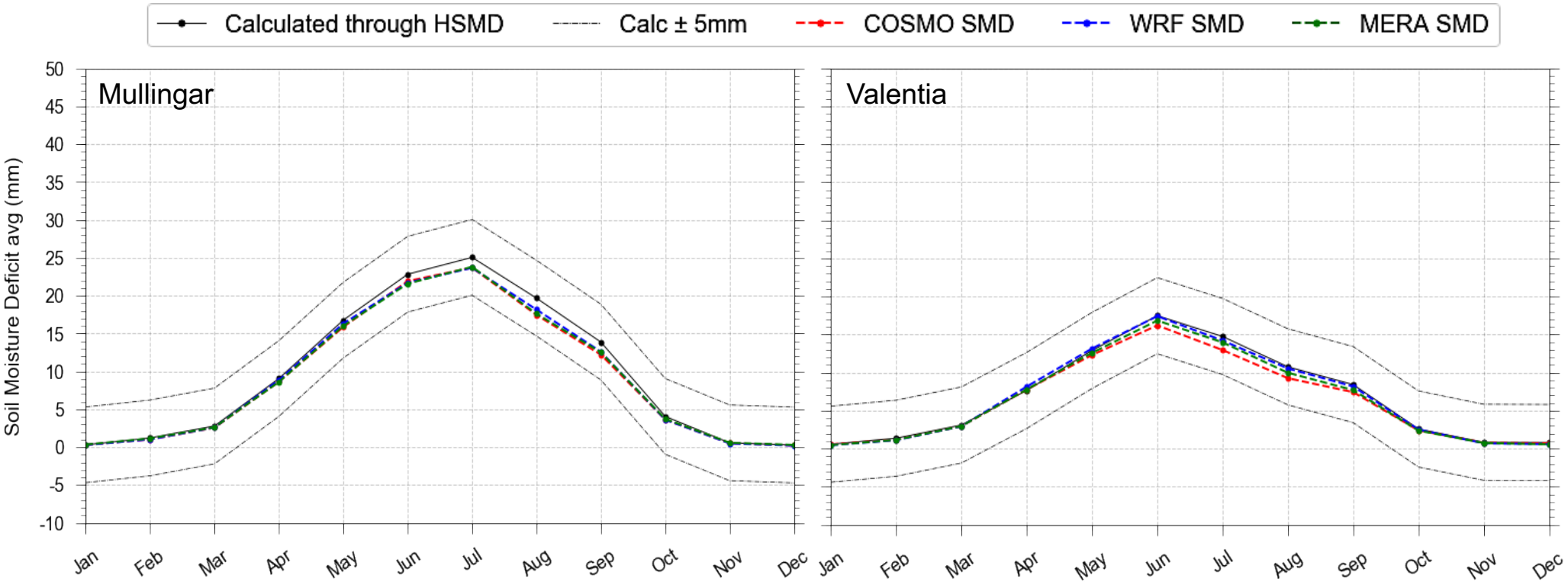
Soil Moisture Deficits (Well Drained)

SMD Average Monthly Means 1981-2016 for MÉRA, WRF and COSMO models (Well Drained)



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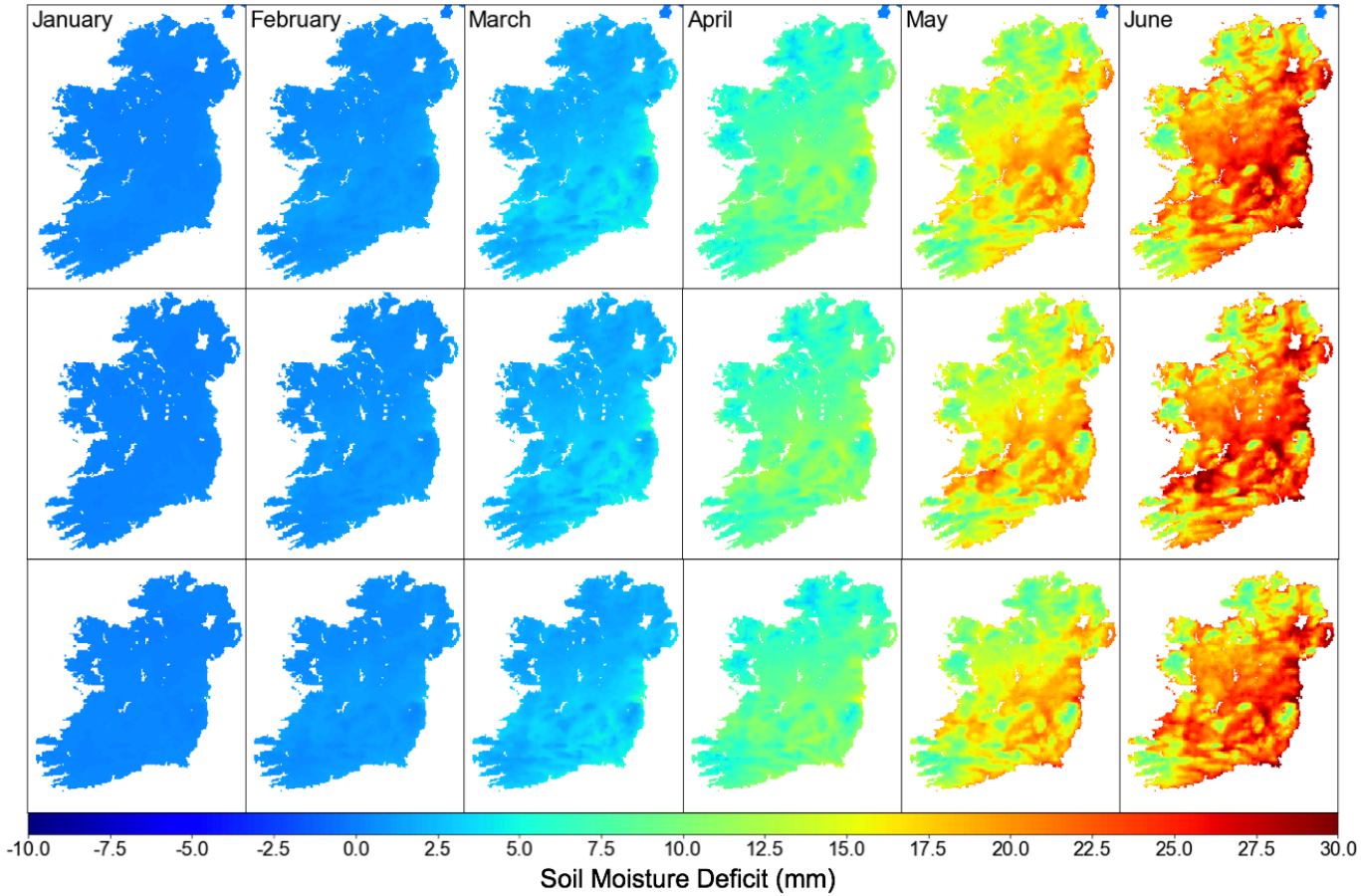
Soil Moisture Deficit (SMD) – Well Drained Mean Monthly Averages 1981-2016

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jan	Feb	Mar	Apr	May	Jun	DAILY	Jan	Feb	Mar	Apr	May	Jun
COSMO		0.374	0.754	0.893	1.434	2.219	2.998		0.642	1.132	1.628	2.333	3.07	3.995
WRF		0.411	0.81	0.877	1.300	1.918	2.554		0.675	1.145	1.542	2.155	2.801	3.556
MÉRA		0.339	0.668	0.796	1.274	1.84	2.354		0.591	1.014	1.489	2.127	2.705	3.353

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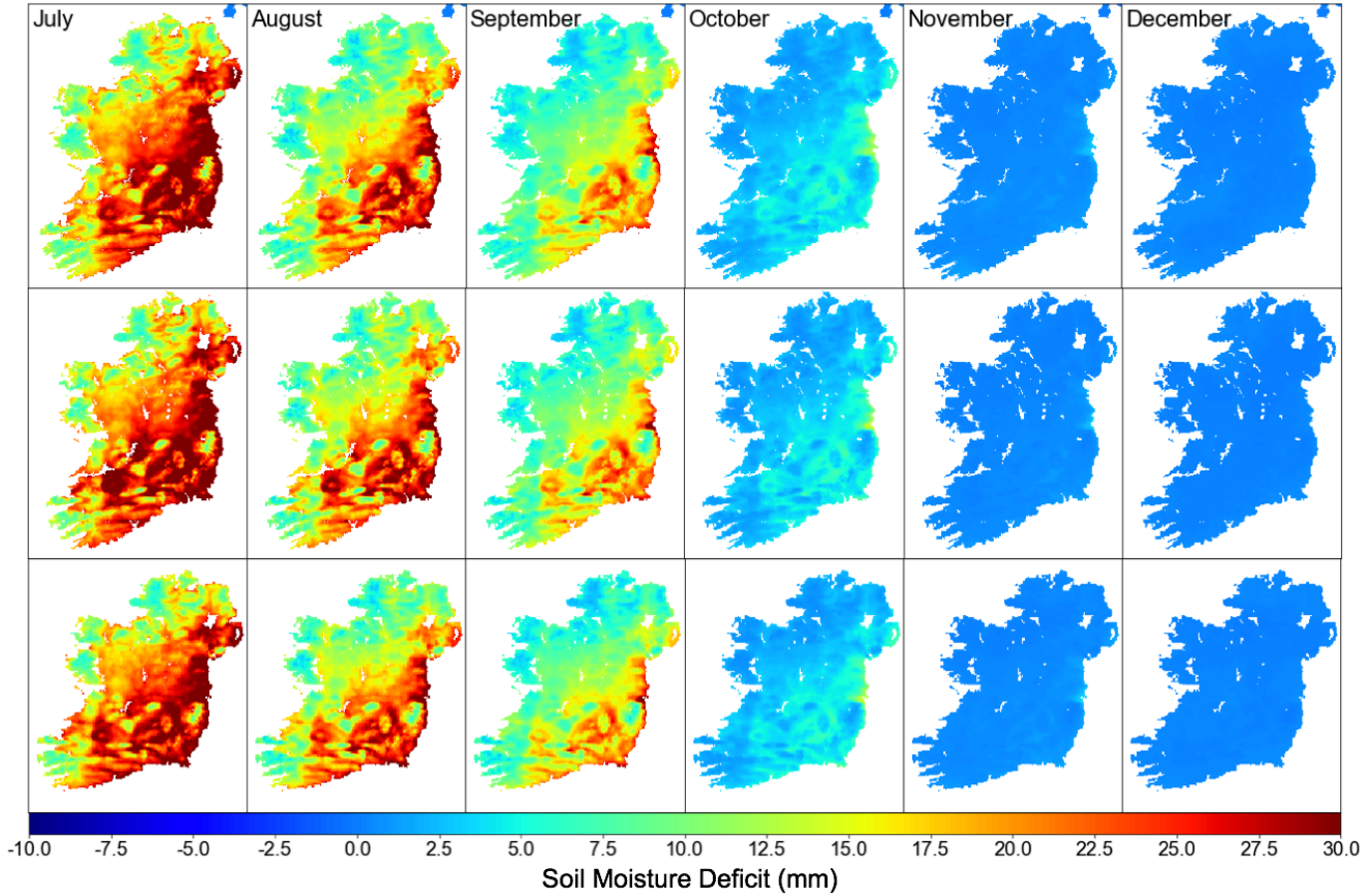
Soil Moisture Deficit (SMD) – Well Drained Mean Monthly Averages 1981-2016

COSMO →

WRF →

MÉRA →



Model	MONTHLY	Jul	Aug	Sep	Oct	Nov	Dec	DAILY	Jul	Aug	Sep	Oct	Nov	Dec
COSMO		2.912	2.875	2.457	1.166	0.389	0.377		3.77	3.842	3.338	1.892	0.765	0.677
WRF		2.452	2.301	1.956	1.069	0.512	0.454		3.427	3.35	2.909	1.782	0.863	0.767
MÉRA		2.24	2.301	2.077	1.027	0.407	0.407		3.246	3.329	3.015	1.758	0.758	0.701

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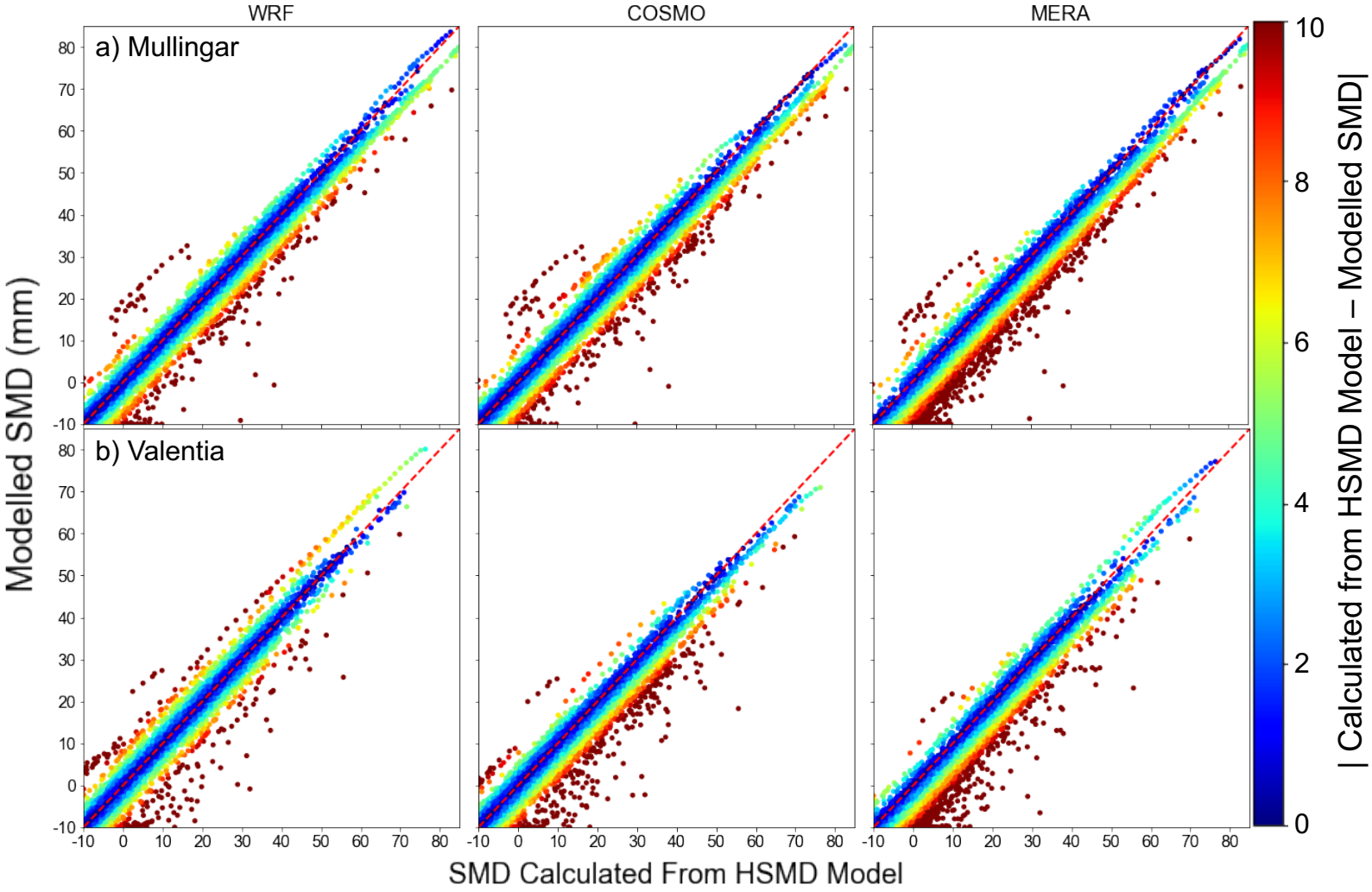
Soil Moisture Deficits (SMD) Daily Scatter Plots (Poorly Drained)



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Data Hosting

- ICHEC will host data via Earth System Grid (ESGF)
- Software written to reprocess netcdf files to compliant format
- Other downscaling available provided by ICHEC and Maynooth University
- ESGF will make the data publicly available, indexed globally
- Notifications of availability will be made through project page on www.ichec.ie and Twitter @ichec

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Additional Work

Agroclimatic Atlas for Ireland

- Discussed parameters to be included in Atlas
- Updates to precipitation, temperature maps
- Updates to essential climate variables

Standarized Precipitation Index (SPI)

- International best practice for drought indicator
- Uses also in looking at flood risk modelling
- Work in progress for all three models over 1,2,3…48 month time windows

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Summary

- ICHEC will be hosting High Resolution Gridded Datasets of Hydroclimatic Variables via Earth System Grid (esgf.ichec.ie)
- Variables will include;
  - ET_0
  - ET_a (x 5 drainage classes)
  - SMD (x 5 drainage classes)
  - Standardized Precipitation Index (SPI) (in progress)
- ET_0, ET_a, and SMD calculated over daily, monthly, seasonal, and yearly timesteps
- SPI calculated over 1,2,3…48 month timesteps
- Datasets derived using MÉRA considered as best datasets, with ICHEC's WRF as worthy alternative
- Datasets will help to facilitate update to the Agroclimatic Atlas for Ireland
- Updates on availability will be made on project page www.ichec.ie and Twitter @ichec