



Making Ireland Weather  
and Climate Prepared

# IMPLEMENTING THE TSSF MODEL AT ECMWF

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# INTRODUCTION

- Introduction
- Overview of the Tidal and Storm Surge Forecast (TSSF) Service
- Feasibility Trial at European Centre for Medium-range Weather Forecast (ECMWF)
- An Operational TSSF Suite
- On-going & Future Development



# INTRODUCTION

The Irish government made a decision in 2016 to establish a National flood forecasting and Warning Service

The operational element of the NFFWS was setup in Met Éireann as the Flood Forecast Division

- The Meteorological Service for Ireland
- Weather expertise
- 24/7 Operational service
- Public trust
- Public engagement



# INTRODUCTION

## Flood Forecast Division (FFD) – Stage 1

- Recruitment and Training
- Develop the river models for use at National and Catchment level
- Develop a Communication Strategy for the NFFWS
- Trial and Test our Flood Forecasting Capabilities, Procedures, and Systems
- Introduce National Coastal modelling into the suite of operational forecast models



# OVERVIEW OF THE TSSF

## The TSSF is the Tidal and Storm Surge Forecast Service for Ireland

- Provides forecasts for tides, residual surge and total water level
- Developed and operated by RPS on behalf of the OPW
- Comprises a MIKE 21 flexible mesh modelling system
- Weather forcing using European Centre for Medium-range Weather Forecast (ECMWF) high resolution weather forecasts
- Operating since 2009, with development periodically
- Forecasts disseminated via a website to stakeholders



# OVERVIEW OF THE TSSF

## Decoupled Operation

- Astronomic Tides run in advance – detailed and coarse
- Daily model runs on coarse astronomic tides
  - 72hr am/pm & 144hr surge outlook
- Astronomic Tides used for post-processing

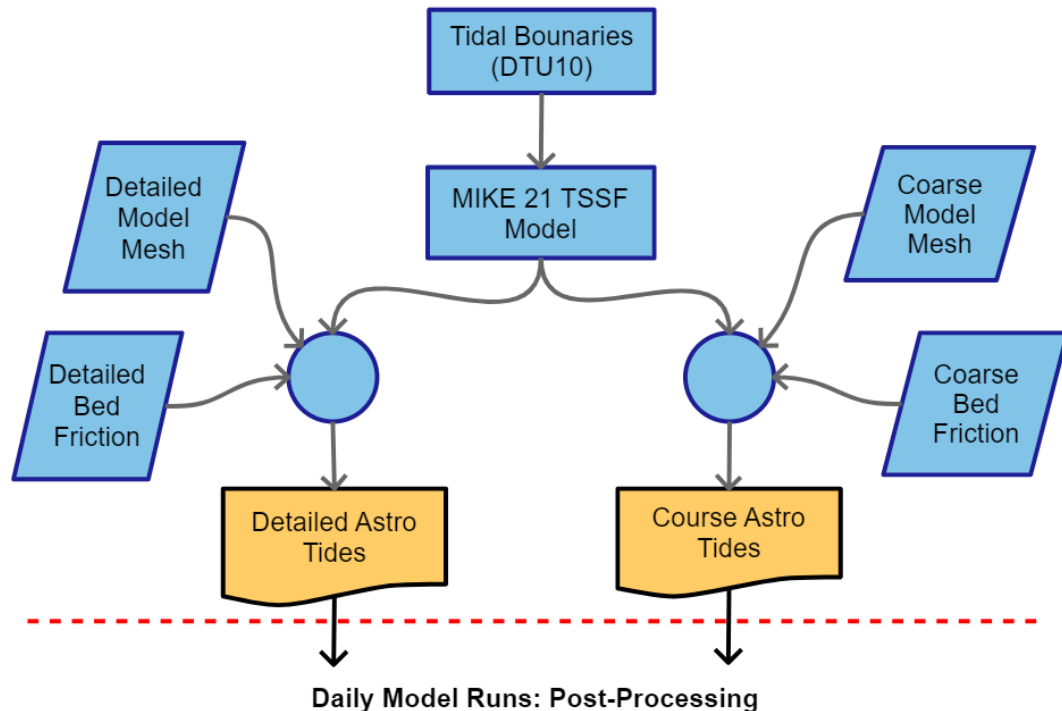


# OVERVIEW OF THE TSSF

## Astronomic Tides

- Run in advance
- Detailed and Coarse
- No weather forcing

## ASTRONOMIC TIDES

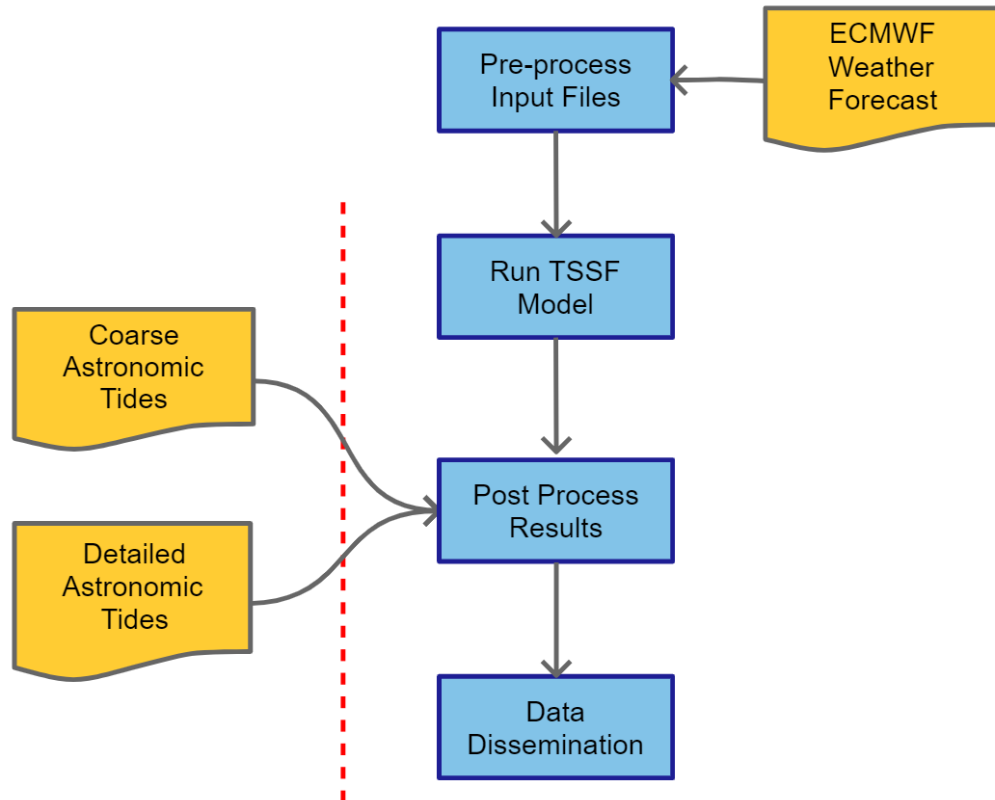


# OVERVIEW OF THE TSSF

## Daily Model Runs – 4 Tasks

- Pre-processing the weather forecast
- Run the TSSF model
- Post Process the results
- Disseminate the data to the website

## DAILY MODEL RUNS



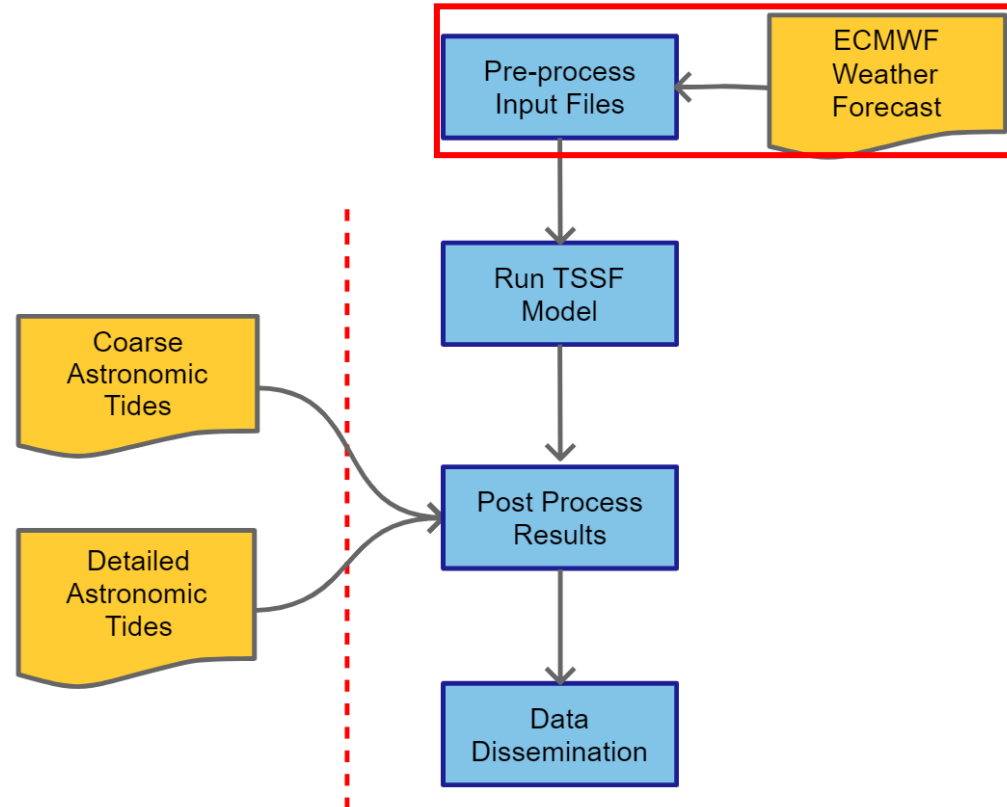


# OVERVIEW OF THE TSSF

## Pre-processing the Weather Forecast

- Applying a wind scaling factor
- Conversion to dfs2 for model input

## DAILY MODEL RUNS

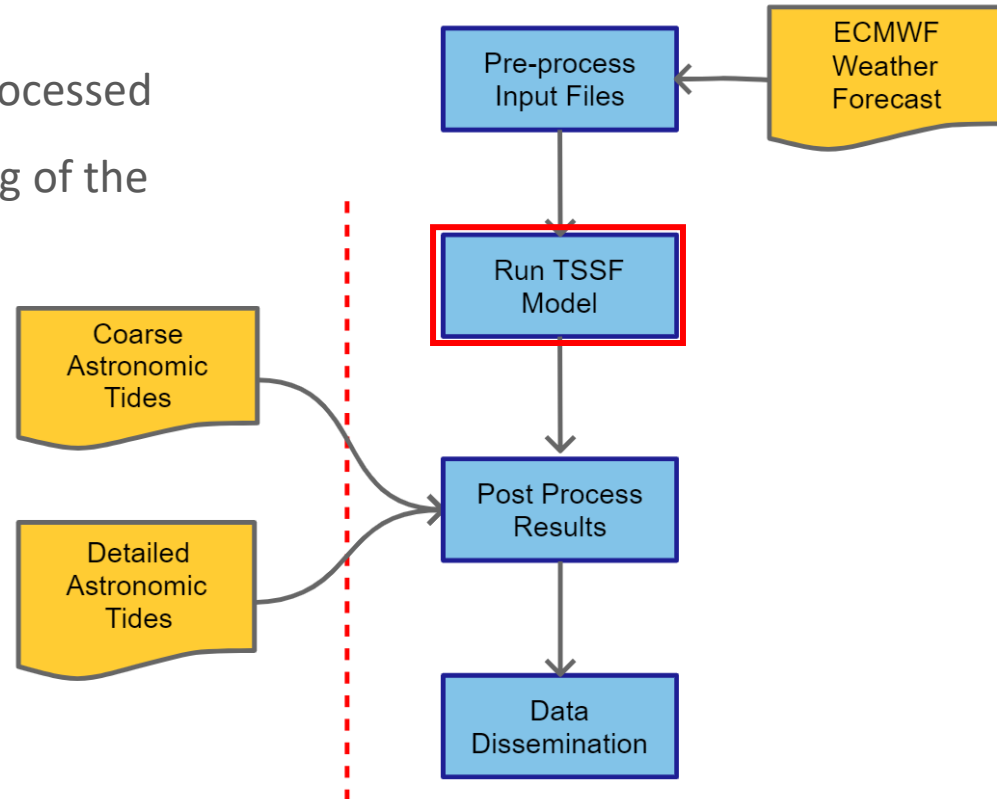


# OVERVIEW OF THE TSSF

## Run the TSSF Model

- The model can be run after the pre-processed weather forecast is available for forcing of the model.

## DAILY MODEL RUNS

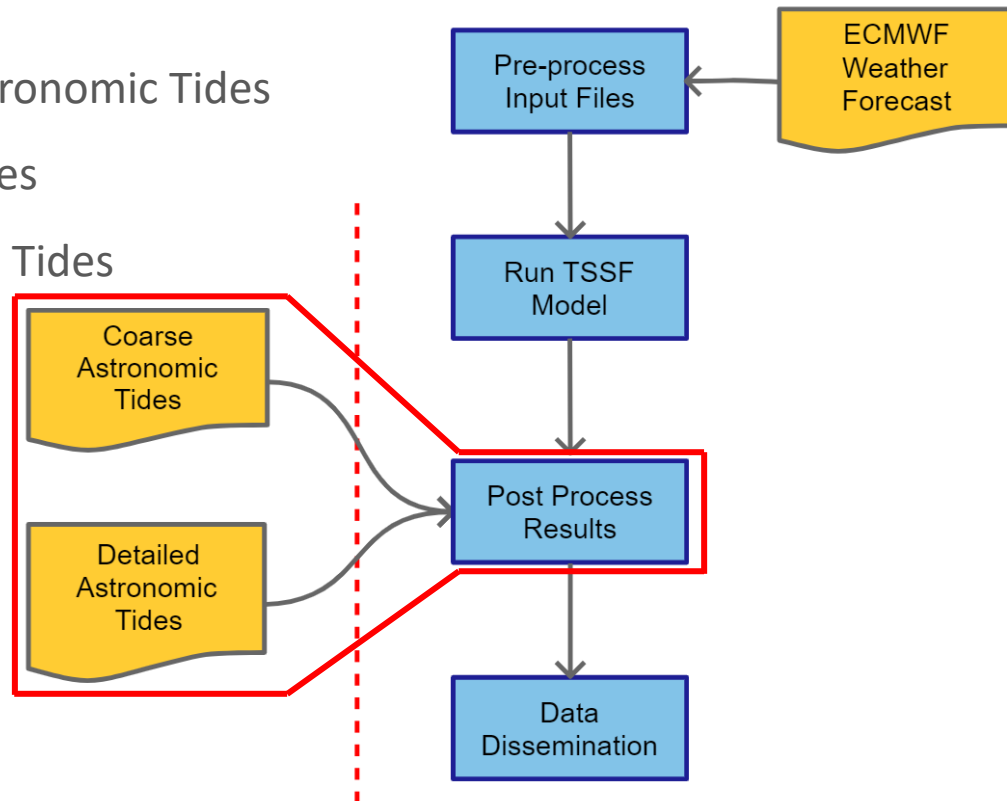


# OVERVIEW OF THE TSSF

## DAILY MODEL RUNS

### Post-processing Results

- Surge = Daily Model results – coarse Astronomic Tides
- TWLs = Surge + Detailed Astronomic Tides
- Astronomic Tides = Detailed Astronomic Tides

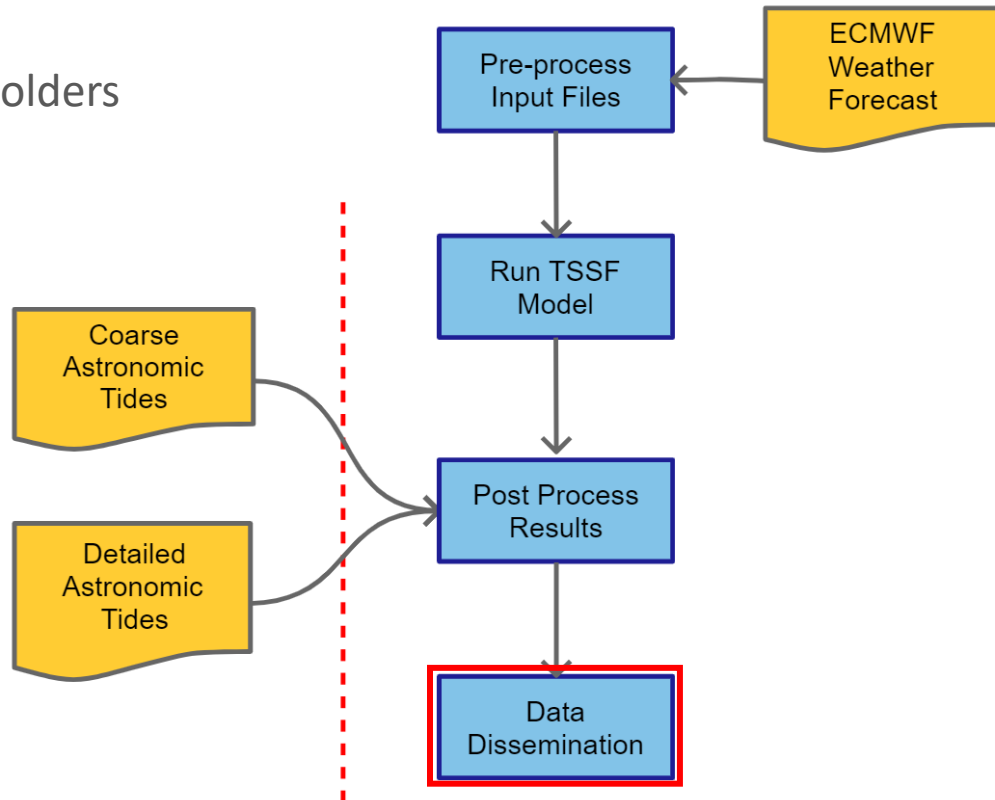


# OVERVIEW OF THE TSSF

## Data Dissemination

- The results are disseminated to stakeholders

## DAILY MODEL RUNS



## FEASIBILITY TRIAL AT ECMWF

The Office of Public Works(OPW) with Met Éireann commissioned RPS to support a study to ascertain the feasibility of porting the TSSF system to run in the high performance computing (HPC) environment at ECMWF.

### ECMWF

- 24/7 Monitoring
- Redundancy



# FEASIBILITY TRIAL: STAGE 1

## Stage 1: Establish DHI MIKE 21 compatibility within the ECMWF HPC environment

- Challenges:
  - Linux environment (installation / dependencies)
  - Internet Licencing (ECMWF staff support)
- MIKE 21 successfully installed and tested



# FEASIBILITY TRIAL: STAGE 1

## Benchmarking tests of model performance

- Forecasts compared to RPS operational forecast at multiple locations
- The TSSF at ECMWF produced identical forecasts to the RPS operational service



## FEASIBILITY TRIAL: STAGE 2

### Stage 2: Automation of TSSF Model

- Schedule daily runs (unattended operation)
- Challenges
  - Standard weather forecast data conversion tools not available (Linux). RPS provided processed weather forecast data for the trial
- Trial ran successfully from 9<sup>th</sup> to 31<sup>st</sup> July 2020
- Deviations with the operational forecast was in the order of millimetres





## FEASIBILITY TRIAL: STAGE 3

### Stage 3: Post-processing results

- Challenges
  - Standard tools not available in the Linux environment
- OPW requested DHI develop a Linux post-processing tool to convert model output to ASCII format
- Met Éireann developed scripts for the arithmetic calculations to provide the forecast astronomic tides, residual surge and TWLs.



## FEASIBILITY TRIAL: STAGE 3

- Test Dissemination of forecasts to external users
- Dissemination was tested on clone of the operational website provided by RPS.
- Successful dissemination over the trial.



## FEASIBILITY TRIAL: STAGE 3

### Further developments (after Stage 3)

- A Linux tool to convert weather forecast grib files to dfs2 format was developed collaboratively by DHI and Met Éireann for pre-processing.

### Feasible to run the TSSF at ECMWF

- Trial Successful



# AN OPERATIONAL TSSF SUITE

## ECMWF Time Critical Operational Suites

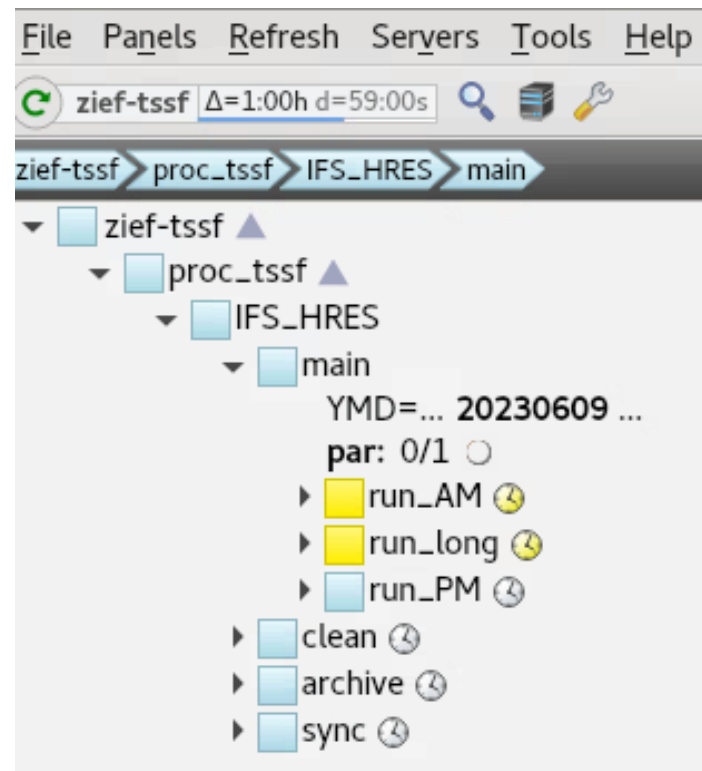
- Develop as a suite in ecFlow
- ecFlow System at ECMWF
  - Scheduling Workflow
  - Monitoring (24/7)
  - System Redundancy



# AN OPERATIONAL TSSF SUITE

## TSSF as an suite in ecFlow

- Families of tasks for the am/pm and outlook surge run (run\_long)
- Scheduling and triggering of the tasks
- Trial and error
- Approved October 2022



# AN OPERATIONAL TSSF SUITE

ECMWF Cray (Reading, UK) -> ECMWF BullSequana XH2000 (Bologna, Italy)

- Mid-development transfer
  - 7,680 compute nodes (>1m CPU cores)
  - Higher Speed CPU Cores
  - 72hr model – 17 minute runtime
- New Linux environment
  - Additional development required



# AN OPERATIONAL TSSF SUITE

## TSSF Suite – Morning Model Run

- Check all weather forecast data received
- Pre-process the weather forecast data
- Run the TSSF model
- Post-process the model results
- Transfer the results files to IFICS for display and visualisation

```

run_AM 🕒
  par: 0/1 ○
  time 06:35 # free
  ▼ tssf_check_input ▲
    LL: 36
  ▼ tssf_pre_proc ▲
    tssf_check_input ==complete
  ▼ tssf_run ▲
    tssf_pre_proc ==complete
  ▼ tssf_post_proc ▲
    tssf_run==complete
  ▶ tssf_file_transfer ▲
  
```



# AN OPERATIONAL TSSF SUITE

## Dissemination – Irish Flood Integrated

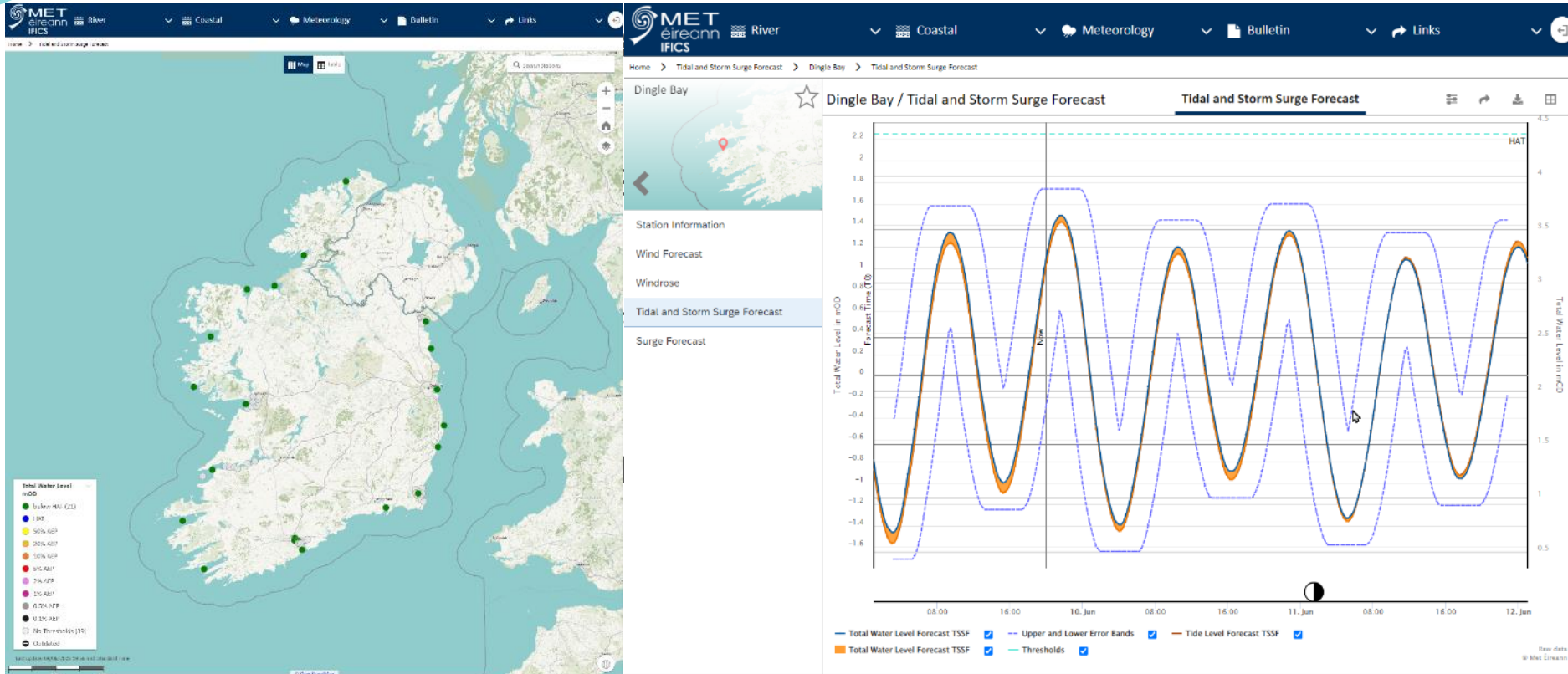
### Communication System (IFICS)

- Display and visualise forecasts in IFICS alongside:
  - ocean observations
  - forecasts and observations for rivers and meteorology





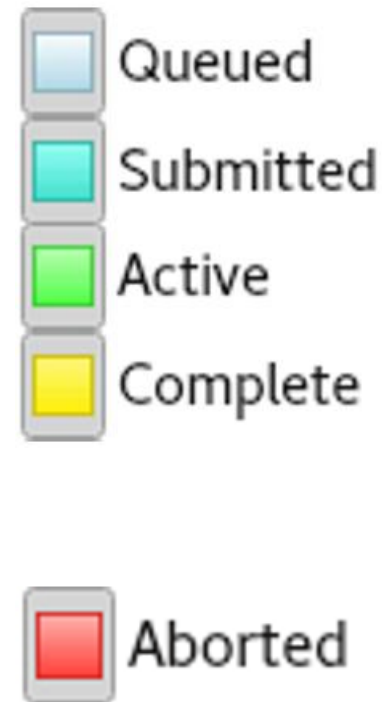
# AN OPERATIONAL TSSF SUITE



# AN OPERATIONAL TSSF SUITE

## Monitoring

- Each task has a status flag
- The flag updates as the task runs
- Provide for easy monitoring of the TSSF



# AN OPERATIONAL TSSF SUITE

## Troubleshooting

- Log files are created for each task
- Operator guidance provided for troubleshooting

```

zief-tssf proc_tssf IFS_HRES main run_AM tssf_run
Info Manual Script Job Job status Output Why
File: /home/zief/tssf_work/proc_tssf/IFS_HRES/main/run_AM/tssf_run.1 Size: 23 KB
Source: read from disk at 2023-06-09 18:38:18
+ echo 'run = 72am'
run = 72am
+ wait
+ ecflow_client --complete
+ trap 0
[ECMWF-INFO -ecepilog] -----
[ECMWF-INFO -ecepilog] This is the ECMWF job Epilogue
[ECMWF-INFO -ecepilog] +++ Please report issues using the Support portal
[ECMWF-INFO -ecepilog] +++ https://support.ecmwf.int
[ECMWF-INFO -ecepilog] -----
[ECMWF-INFO -ecepilog] Run at 2023-06-09T06:51:39 on ac
[ECMWF-INFO -ecepilog] JobName                : /home/zief/tssf_work/
[ECMWF-INFO -ecepilog] JobID                   : 33516703
[ECMWF-INFO -ecepilog] Submit                  : 2023-06-09T06:35:34
[ECMWF-INFO -ecepilog] Start                   : 2023-06-09T06:35:36
[ECMWF-INFO -ecepilog] End                     : 2023-06-09T06:51:39
[ECMWF-INFO -ecepilog] QueuedTime              : 2.0
[ECMWF-INFO -ecepilog] ElapsedRaw              : 963
[ECMWF-INFO -ecepilog] ExitCode                : 0:0
[ECMWF-INFO -ecepilog] DerivedExitCode         : 0:0
[ECMWF-INFO -ecepilog] State                   : COMPLETED
    
```

```

zief-tssf proc_tssf IFS_HRES main run_AM tssf_check_input
Info Manual Script Job Job status Output Why Trigger
File: /home/zief/metapp/tssf/develop/share/ecf/tssf_check_input.ecf Size: 9 KB Modified: 2022-09-
Source: read from disk Lookup method: ECF_FILES(PRUNE_ROOT)
13 #####
14 # Operator Details
15 #####
16 Possible errors:
17     The listen directory does not exist or is not reachable.
18
19 What to do:
20     If the task runs out of patience (2 hours) while waiting for the listen
21     directory to be created, investigate the cause of the delay.
22     Queue the task once any filesystem issues are resolved.
    
```



# ON-GOING & FUTURE DEVELOPMENT

## On-going Work

- Operational October 2023
- Recently Implement data transfer to IFICS
- Testing compatibility with new release cycle of the ECMWF weather forecasts



# ON-GOING & FUTURE DEVELOPMENT

## Future Development

- Introduce the HARMONIE weather forecast model and ensemble members
  - 54 hour forecast
  - Higher resolution and frequency
  - 16 ensembles
  - Confidence
- Test and evaluate using the detail mesh and bed friction for the daily model runs



# Fin

**THANK YOU FOR YOUR TIME!**

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